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Final

Environmental Investigation Report for Fort Douglas

Volume I
Text

Fort Douglas
Environmental Investigation/Alternatives Analysis

Contract No. DAAA15-90-D-0018
Task Order 0005, Data Item A009

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FINAL ENVIRONMENTAL INVESTIGATION REPORT

MARCH 1994

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FORT DOUGLAS
ENVIRONMENTAL INVESTIGATION/ALTERNATIVES ANALYSIS

Volume I
Text

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U.S. ARMY ENVIRONMENTAL CENTER

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LIST OF ACRONYMS AND ABBREVIATIONS

AA	Alternatives Analysis
ACM	asbestos containing material
ARAR	Applicable or Relevant and Appropriate Requirements
ASTM	American Society for Testing and Materials
ATM	alpha track monitors
ATSDR	Agency for Toxic Substances and Disease Registry
BTEX	benzene, toluene, ethylbenzene, and xylenes
CDI	Chronic Daily Intake
CERCLA	Comprehensive Environmental Response, Compensation, and Liability Act of 1980
CFR	Code of Federal Regulations
cfs	cubic feet per second
CLP-M	Contract Laboratory Program Modification
cm^2	square centimeters
CO	commissioned officer
COC	Chemical of Potential Concern
C-O-C	Chain-of-Custody
CRL	Certified Reporting Limit
DEH	Directorate of Engineering and Housing
DOMW	(Fort) Douglas Monitoring Well
DQO	data quality objective
E	exposure level
EI	Environmental Investigation
EP	extraction procedure
ESE	Environmental Science and Engineering, Inc.
FEIS	Final Environmental Impact Statement
ft	feet
ft bgs	feet below ground surface
GC	Gas Chromatography
GC/MS	Gas Chromatography/Mass Spectrometry
HASP	Health and Safety Plan

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

HEAST	Health Effects Assessment Summary Tables
HI	hazard index
HSA	hollow-stem auger
HUD	Department of Housing and Urban Development
ICF	ICF Technology, Incorporated
ID	inside diameter
in.	inch, inches
IRDMIS	Installation Restoration Data Management Information System
IRIS	Integrated Risk Information System
LOAEL	Lowest-Observed-Adverse-Effect-Level
LSA	low specific activity
mL	milliliter
NCO	noncommissioned officer
NCP	National Oil and Hazardous Substance Pollution Contingency Plan
NEPA	National Environmental Policy Act
NIST	National Institute of Standard Technology
NOAEL	No-Observed-Adverse-Effect-Level
OSWER	Office of Solid Waste and Emergency Response
PA	Preliminary Assessment
PAH	polycyclic aromatic hydrocarbon
PCB	polychlorinated biphenyl
pCi/L	picocuries per liter of air
PID	photoionization detector
ppb	parts per billion
ppm	parts per million
QA	quality assurance
QAO	Quality Assurance Officer
QAP	Quality Assurance Program
QAPP	Quality Assurance Project Plan
QC	quality control
RCRA	Resource Conservation and Recovery Act
RD	relative difference

LIST OF ACRONYMS AND ABBREVIATIONS (continued)

RfD	Reference Dose
RLSA	R.L. Stollar and Associates (presently Watkins-Johnson Environmental, Inc.)
SAP	Sampling and Analysis Plan
SARA	Superfund Amendments and Reauthorization Act
SF	Slope Factor
SLC	Salt Lake City
SVOC	semivolatile organic compound
TCL	Target Compound List
TCLP	Toxicity Characteristic Leaching Procedure
TPH	Total Petroleum Hydrocarbons
U/BK	Uptake/Biokinetic
USAEC	United States Army Environmental Center (formerly USATHAMA)
USATHAMA	United States Army Toxic and Hazardous Materials Agency
USCS	Unified Soil Classification System
USDA	United States Department of Agriculture
USEPA	United States Environmental Protection Agency
USGS	United States Geological Survey
USPCI	United States Pollution Control, Inc.
UST	underground storage tank
UU	University of Utah
VOC	volatile organic compound
VRT	Vail Research and Technology Corporation
WJE	Watkins-Johnson Environmental, Inc. (formerly R.L. Stollar and Associates Inc.)
95UCL	95th percent upper confidence limit

EXECUTIVE SUMMARY

Fort Douglas, located east of Salt Lake City, Utah, was established in 1862 as an Army installation. The primary mission of Fort Douglas has been to garrison troops, house prisoners of war, serve as headquarters for military units, and function as a support detachment for military activities in the region. No major industrial activities have been conducted at Fort Douglas. Only light industrial operations associated primarily with the maintenance and repair of base facilities and vehicles have been conducted. Fort Douglas is a subinstallation of Fort Carson, Colorado.

Fort Douglas was recommended for closure and realignment by the Defense Secretary's Commission on Base Realignment and Closure in December 1988. As stipulated by Section 120(h) of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), the closure and transfer of the property must be preceded by an evaluation of hazardous substances which are known or suspected to be present at the site. Therefore, under the management of the U. S. Army Environmental Center (USAEC), formerly the U.S. Army Toxic and Hazardous Materials Agency (USATHAMA), an Environmental Investigation (EI) and Alternatives Analysis (AA) have been conducted for the excessed area of Fort Douglas, approximately 51 acres. The EI involved the collection, testing and assessment of media in the excessed area of Fort Douglas to determine the nature and extent of areas of potential environmental concern. As part of the EI, a risk assessment was performed to characterize risk to human health.

The excessed acreage was conveyed to the University of Utah on November 5, 1991, in accordance with Public Laws 101-510 and 101-519. The remaining acreage is retained by the federal government for use as a military Reserve Center for the 96th Army Reserve Command, and four acres will remain as the post cemetery. Upon completion of potential remedial actions, the title and deed for the excessed area will be formally transferred to the University of Utah.

Under the Base Closure Program, previous investigations of Fort Douglas, including an Enhanced Preliminary Assessment (PA), conducted in 1989 by Roy F. Weston, Inc. (Weston), and a Final Environmental Impact Statement (FEIS), conducted in 1991 by Dames and Moore, were used in the design of the EI/AA field program. The EI/AA integrates information from site visits, personnel interviews and the previous studies, which also include a waste site characterization study and a site investigation for five underground storage tank (UST) sites. This information was used to identify five

potential sources of contaminants that could impact the excessed area: 1) two former USTs and a wash rack/oil change/degreasing area near Building 39, 2) waste storage, maintenance, and disposal areas near the southeast fence line of Fort Douglas, 3) a University of Utah storage yard upslope from Fort Douglas, 4) pole-mounted transformers throughout the excessed area potentially containing polychlorinated biphenyls (PCBs) in the dielectric oil, and 5) structures containing asbestos, radon, and lead-based paint. The EI/AA program was designed to investigate these potential contaminant sources.

The EI field work was conducted in two phases, in September and October 1991, and in July 1992. Samples collected from Fort Douglas during the EI included soil, transformer oil, paint wipe, and paint chip samples. A radon sampling program was conducted by Fort Carson. Prior to the EI, asbestos sampling was conducted by Watkins-Johnson Environmental (WJE), formerly R. L. Stollar and Associates (RLSA), and the results are presented and assessed in a separate document (RLSA, 1991d). Subsequent encapsulation was conducted in some of the buildings by Fort Carson. Appendix C of this report contains an information paper by Fort Carson on the asbestos abatement.

No surface-water bodies are located on Fort Douglas. Red Butte Creek is located adjacent to Fort Douglas, less than 150 ft from the excessed area near the southeast fence line. The depth to the regional aquifer is approximately 350 ft; perched ground water is very limited in the area. Therefore, no monitoring wells were installed, and no ground or surface water was sampled.

During the field investigations, surface-soil samples were collected, and soil borings were drilled and sampled to a maximum depth of 29.5 feet below ground surface (ft bgs). Soil sampling was conducted in the Building 39 Area, the Southeast Fence Line Area, downslope of the University of Utah's storage yard, and in locations expected to represent background compound concentrations in soil.

The Building 39 Area was historically used as a service station for vehicle refueling and maintenance. In this location, two USTs formerly containing gasoline and possibly waste oil were permanently closed by removal in August and September 1991. The removal was conducted by Westech Fuel Equipment (Westech), under the direction of Fort Carson. Analytical results from the EI soil samples confirmed the results of previous investigations, which indicated that releases from the tanks to the soil had not occurred. In the wash rack/oil change/degreasing area, pieces of black-stained concrete, likely remnants of the wash rack or grease pit, were recovered from one of the EI borings. Petroleum hydrocarbon compounds, including several polycyclic aromatic hydrocarbons (PAHs), were detected in surface soil

collected directly below the sod and in subsurface soil samples. The highest total petroleum hydrocarbons (TPH) concentration was 500 μg/g. PAH concentrations did not exceed 0.35 μg/g. Chromatogram fingerprints from gas chromatography/mass spectrometry (GC/MS) analyses indicated the hydrocarbons were heavy oils, such as used motor oils or lubricants. Several metals were also detected; however, the concentrations were near or within the range of concentrations detected in background soils at Fort Douglas.

Several maintenance and hydrocarbon storage areas, located on the retained area, are adjacent to excessed property near the southeast boundary of the post. Potential releases and migration of contaminants from paved drum and fuel storage areas, waste oil USTs, and a parking/storage lot (all on the retained area) were investigated by drilling and sampling four shallow soil borings (maximum depth of 4.0 ft bgs) and collecting 15 surface-soil samples.

Samples were collected at three downslope locations on the excessed area with the highest probability to receive contamination runoff from the retained area. At one location, three soil samples were collected at the end of a culvert, which extends from a wash rack and sump at the parking/storage lot to the southeast fence line. No PAHs or elevated levels of TPH were detected in these samples, and metals concentrations were near or within the ranges detected in background soil samples, indicating drainage from the culvert was not a source of contamination to the excessed area.

At the second location, samples from a soil boring and four surface soil samples were collected from soil within and near a concrete drainage ditch to investigate runoff from a hydrocarbon storage area, formerly containing two waste oil USTs. Fresh oil and solvents also were reportedly stored in this area. One remaining UST was permanently closed by removal in August and September 1991, by Westech. Soil samples collected during closure indicated a maximum TPH concentration (oil and grease) of 10,000 μg/g. Most of the contaminated soil was removed during over-excavation; however, at the south end of the area, removal was not complete due to fence lines, power poles and lines, and trees. TPH and benzene, toluene, ethylbenzene, and xylene (BTEX) were not detected in samples from borings surrounding the excavation. Near the concrete drainage ditch on the excessed area, the surface soil sample from the EI boring contained TPH at a concentration of 600 μg/g. In the subsurface sample, PAHs were not detected, and the TPH concentration was 20 μg/g. Several PAHs were detected in three of the surface soil samples. Concentrations of the PAHs did not exceed 0.4 μg/g; the highest concentrations were detected in a sample collected from soil infilling the concrete ditch. The highest TPH

concentration in these samples was 200 μg/g. Mercury was detected above levels measured in the background soils in one of the surface soil samples, at a concentration of 0.151 μg/g. Concentrations of other metals were near or within the ranges detected in background soil samples.

At the third location near the southeast fence line, samples from two soil borings and nine surface soil samples were collected to investigate drum and fuel storage areas adjacent to the excessed area. Man-made or used materials, including pieces of brick, ceramic, coal, cast iron pipe, and masonry were present in the soil boring samples, indicating this area may have been used for disposal of post waste. In addition, three used oil filters were on the ground near these locations. TPH concentrations in the surface soil samples ranged up to 6,000 μg/g. In the subsurface soil samples, the highest concentration was 1,000 μg/g. Chromatogram fingerprints from GC/MS analyses indicated the hydrocarbons primarily were heavy oils. Several PAHs were detected in surface and subsurface soil; concentrations did not exceed 0.25 μg/g. Reported concentrations of lead, zinc, mercury, chromium, and silver were above the range of concentrations detected in background soils at Fort Douglas. Concentrations of other metals were near or within the ranges detected within the background soils.

During the initial field effort, debris was noted in several of the soil borings drilled in the Southeast Fence Line Area. Additional interviews revealed that Fort Douglas post trash (including coal, ceramics, glass bottles, animal bones, and a rifle casing, as observed during the EI field program in July 1992) was dumped near Red Butte Creek until approximately 1940 (Jess McCall, curator, Fort Douglas Military Museum). An additional surface soil sample was collected near the southwest border of this area to analyze potential compounds associated with the coal and other debris. No PAHs were detected in this sample, which was observed to contain coal or coal-like fragments, and TPH were detected at a concentrations of 30 μg/g. Concentrations of metals were near the ranges detected in the background soil samples. These results indicate that the coal and other debris disposed of during the same period are likely not sources of the PAHs and elevated levels of TPH and metals that were detected in other locations in the Southeast Fence Line Area.

Adjacent to the eastern boundary of the post, the University of Utah uses a storage yard for miscellaneous equipment, drums, transformers, and containers of hydraulic fluid and lubricating oil (as observed during site visits). Downslope from the storage yard, a surface soil sample and samples from one boring located on an asphalt parking lot were collected from Fort Douglas. The highest TPH concentration was 60 μg/g. Pyrene was detected at a concentration of 0.080 μg/g in the soil collected directly below the

asphalt. Metals concentrations were near or within the range of concentrations detected in background soils from Fort Douglas.

The analytical results of the soil investigations indicate four potential sources of contaminants to the soil in the excessed area. These include the Building 39 wash rack/oil change degreasing area, the Building 134 UST, the Building 132 storage area, and the adjacent southeast fence line disposal area. The potential contaminants of concern (COC) detected in the soils are heavy petroleum hydrocarbons, PAHs, and metals. These contaminants are typically immobile, slowly biodegradable or nonbiodegradable, persistent, and sorb to soil.

The primary release mechanism in the source areas was likely spills and leaks to soils; the soils may be secondary sources via precipitation runoff and infiltration. The primary migration pathway that may release contaminants is soil. The air pathway is considered to be of minor significance because the sites are covered by natural vegetation or sod, and there is no vehicular traffic in the contaminated areas. Surface water and sediments are not significant migration pathways because no surface-water bodies exist on-site, and, given the limited amount of contamination on-site, it is unlikely that a significant amount of contamination has impacted Red Butte Creek. In addition, the creek is not used for human consumption, and swimming is prohibited. Human exposure to biota and agricultural products are not major exposure pathways because the site is an urban residential/institutional area, and it is unlikely the contaminated areas would be used for gardening. Ground water is not considered a primary migration pathway because the depth to the groundwater aquifer is approximately 350 ft bgs, and the detected contaminants would not be expected to travel this distance.

Electric utility transformers were also investigated under the EI/AA program. Polychlorinated biphenyls (PCBs) have historically been used in transformer oil due to their physical and chemical properties. Therefore, samples of transformer oil from 24 pole-mounted transformers in the excessed area of Fort Douglas were collected and analyzed for PCBs. One mixture of PCBs was detected, PCB 1260, at a concentration of 200 $\mu g/g$ in samples from two transformers. These transformers were observed to be in poor to fair condition. Oil stains were noted on the outsides of the transformers around the bushings, but there was no indication from the stains that the transformer oil had reached the ground. No stained soil was observed below the transformers.

Paints containing lead as a major ingredient were commonly used until 1971, when the content of lead in paint was regulated. Paint chip and paint wipe samples confirmed the presence of lead-based paints in the structures at Fort Douglas. Lead concentrations in paint chip samples ranged up to 400,000 $\mu g/g$ or 40 percent lead by weight. In the wipe samples, lead was measured up to a concentration of 0.5 $\mu g/cm^2$ (400 $\mu g/ft^2$). Lead was measured at 500 $\mu g/g$ (0.05 weight percent) and at 50,000 $\mu g/g$ (5 weight percent) in two exterior samples of paint.

As part of the Army Radon Reduction Program, radon levels at numerous installations are being investigated. High concentrations of indoor radon have frequently been measured in structures located near the Wasatch Mountains, in the Salt Lake City area. Fort Carson conducted short-term (4-day) and long-term (one-year) sampling programs at Fort Douglas. The highest measurement from the short-term program was 4.0 picocuries per liter of air (pCi/L). The highest measurement from the long-term program was 7.2 pCi/L. Structures with radon levels measuring 3.3 pCi/L and above during the long-term monitoring program have been mitigated by Fort Carson. The mitigated structures are being retested for an additional year to determine if the remedial actions reduced the radon levels.

A risk assessment evaluated the health risks associated with soil contamination. Asbestos was not addressed by this risk assessment because the risks were evaluated previously, as identified in the Asbestos Survey Results report (RLSA, 1991d), and limited corrective actions have been performed in some of the buildings (Appendix C). Radon data were not assessed for similar reasons. The radon data were evaluated by Fort Carson according to United States Environmental Protection Agency (USEPA) guidelines, remedial actions were performed, and follow-up monitoring is being conducted to assess the effectiveness of the actions in reducing radon levels. In addition, it is inappropriate to conduct a risk assessment using the transformer oil data because transformers are not considered environmental media, and release of transformer oil to the soil was not observed.

Three separate exposure scenarios were evaluated in the risk assessment: a residential, an industrial, and a recreational scenario. These scenarios were chosen as a basis for estimating exposure at the site based on current and projected (i.e., future) land uses. Under each of the three exposure scenarios, two exposure pathways were evaluated quantitatively: incidental ingestion of contaminated soil and dermal absorption of contaminants in soil.

A toxicity assessment of the soil COCs indicated that both cancerous and noncancerous adverse health effects are of potential concern at the site, if exposure were to occur in sufficient quantities. Some of the COCs are classified as probable human carcinogens (USEPA class "B2"), but none are classified as known human carcinogens (USEPA class "A"). In addition, some of the COCs are associated with systemic toxicity (i.e., noncancerous effects), including alterations in liver function, kidney function, and hematopoietic (i.e., blood) parameters.

The risk characterization revealed that the potential for cancerous effects was highest under the residential scenario. The probability of developing cancer for potential residents of Fort Douglas was calculated to be 1E-6 for the Building 39 Area and 2E-6 for the Southeast Fence Line Area, assuming a 30-year on-site residency. The probabilities of developing cancer under the industrial and recreational scenarios were calculated to be 4E-7 and 3E-7, respectively, for the Building 39 Area, and 6E-7 and 4E-7, respectively, for the Southeast Fence Line Area. All of these cancer risk estimates fall within, or below the acceptable range of 1E-6 to 1E-4, as defined by the USEPA.

Evaluation of noncarcinogenic risks, expressed as Hazard Quotients, indicates that exposure to the COCs is unlikely to result in adverse health effects. All Hazard Quotients calculated for Fort Douglas are markedly less than one. If a Hazard Quotient exceeds one, then there may be a concern for noncancerous health effects. The highest Hazard Quotient was calculated to be 0.00009 under the residential scenario.

While soil lead levels at the site are well below current USEPA guidelines for soil, as established by the Office of Solid Waste and Emergency Response (OSWER) Directive 9355.4-02, the levels of lead detected in some paint chip samples collected from the buildings exceed Department of Housing and Urban Development (HUD) criteria for defining a lead-based paint hazard in building interiors. In addition, lead-based paint on buildings at a federal facility is regulated by federal law (Lead-Based Paint Poisoning Prevention Act) when the property is sold (or transferred).

This Environmental Investigation Report has been reviewed by appropriate departments within State of Utah and Federal (USEPA) regulatory agencies. One department—The State of Utah Department of Environmental Quality, Division of Environmental Response and Remediation—asserts that data gaps exist in the Environmental Investigation. Their areas of concern include 1) the regional groundwater aquifer,

2) storage/use of pesticides, and 3) impacts of site contamination on Red Butte Creek. The USAEC maintains that additional investigation of these areas is not necessary, based on the following rationale:

- Investigation of the regional aquifer is unwarranted because 1) the detected contaminants are highly immobile (i.e. they strongly attenuate to soil), and 2) the depth to the regional aquifer is approximately 350 ft. Migration of these contaminants, through this thickness of sediments, is highly unlikely.

- Additional efforts to investigate the storage of pesticides is unwarranted because the pesticides, used for routine application, were stored on the property that is being retained by the Army.

- Investigation of Red Butte Creek is unwarranted because 1) subsurface migration is not towards the creek, 2) surface migration to the creek occurs from many upstream sources, and 3) the contaminants detected in soil near the creek are known to be ubiquitous (near-uniformly present) in metropolitan areas. These factors indicate that additional investigations would be inconclusive, relative to the impact of the site on the creek. Further, because the human and ecologic risk posed by the on-site contamination is below regulatory concern, it is improbable that this risk would be significantly increased by migration to the creek.

The Army believes, based on these and all relevant and probable factors, that it has investigated all foreseeable sources which would potentially pose a significant threat to human health or the environment. Therefore, the Army feels that the requirements for the transfer of the closure (excessed) portion of Fort Douglas to the University of Utah have been met.

1.0 INTRODUCTION

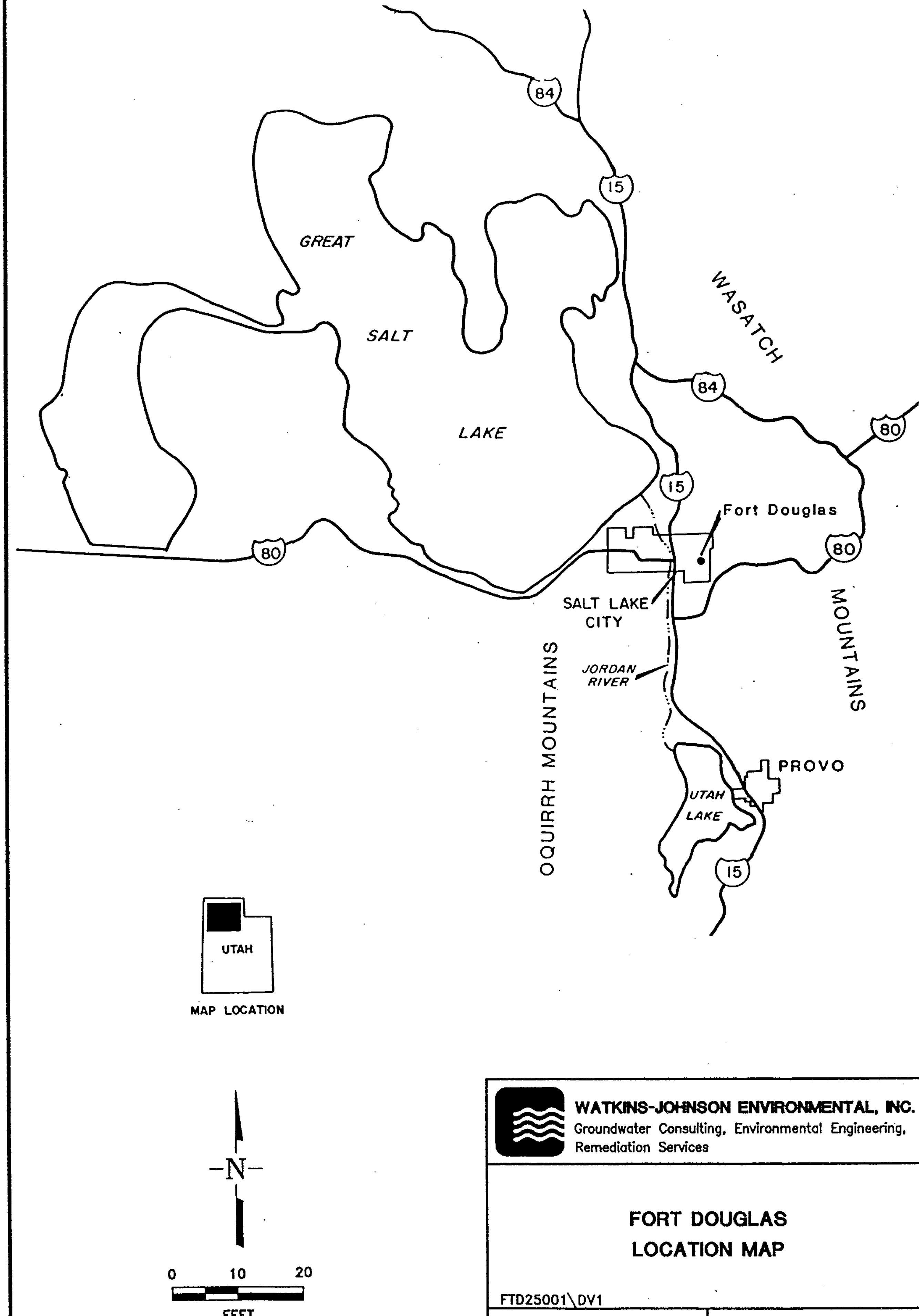
Fort Douglas, an Army installation located east of Salt Lake City, Utah (Figure 1-1) was recommended for closure and realignment by the Defense Secretary's Commission on Base Realignment and Closure in December 1988. The closure and realignment of Fort Douglas, a subinstallation of Fort Carson, Colorado, has resulted in the reassignment of its functions to other installations. Fort Carson has provided, and will continue to provide, environmental support to Fort Douglas. Upon closure on November 5, 1991, 51 acres of the 119-acre Fort Douglas installation (Figure 1-2) were conveyed to the University of Utah; however, the title has not yet been transferred. The remaining acreage is retained by the federal government for use as a military Reserve Center for the 96th Army Reserve Command, and four acres will remain as the post cemetery.

In order to facilitate the closure of Fort Douglas, an enhanced Preliminary Assessment (PA) and Final Environmental Impact Statement (FEIS) were completed. Based on the recommendations of the PA, an Environmental Investigation/Alternatives Analysis (EI/AA) program was conducted. This program is administered by the U.S. Army Environmental Center (USAEC) (formerly the U.S. Army Toxic and Hazardous Materials Agency [USATHAMA]), which has the authority for centrally managing the environmental investigation portion of the Base Closure Program.

1.1 PURPOSE

The purpose of the Fort Douglas EI/AA is to identify potential environmental liabilities associated with the transfer of the excess property. The EI/AA was conducted by Watkins-Johnson Environmental, Inc. (WJE) (formerly R.L. Stollar and Associates [RLSA]) in three phases: an EI, a risk assessment, and an AA. The EI involved the collection, testing and assessment of media at Fort Douglas to determine the nature and extent of areas of environmental concern. The risk assessment involved the characterization of risk to human health. The alternatives analysis involved the development and evaluation of applicable remedial strategies. The contamination assessment and risk assessment are contained in this EI document. The AA is contained in a separate, companion document.

Under the same task, an asbestos evaluation was conducted by WJE prior to and independently of the EI/AA. An Asbestos Sampling Plan (RLSA, 1991a) was developed, and the results and risk assessment

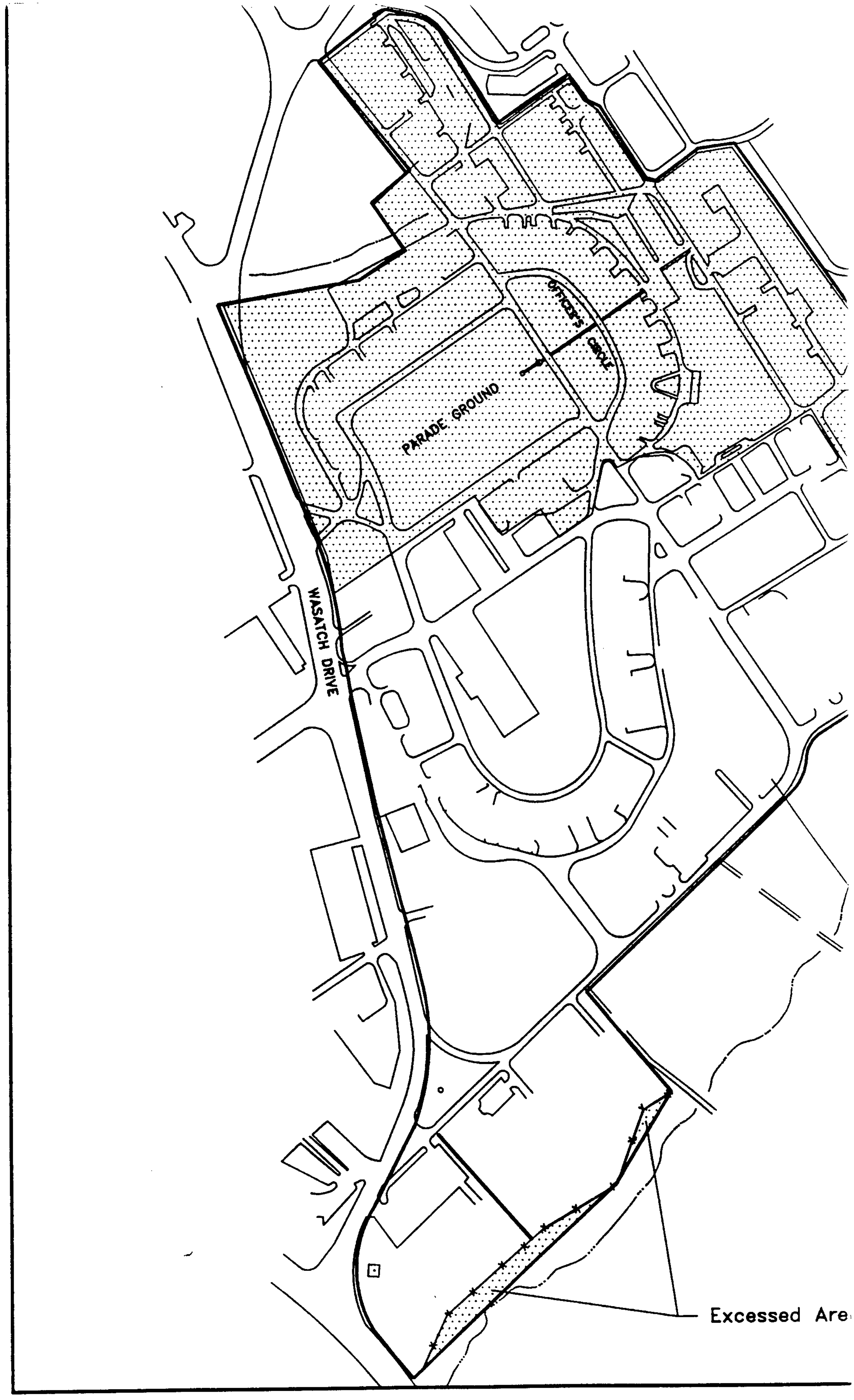


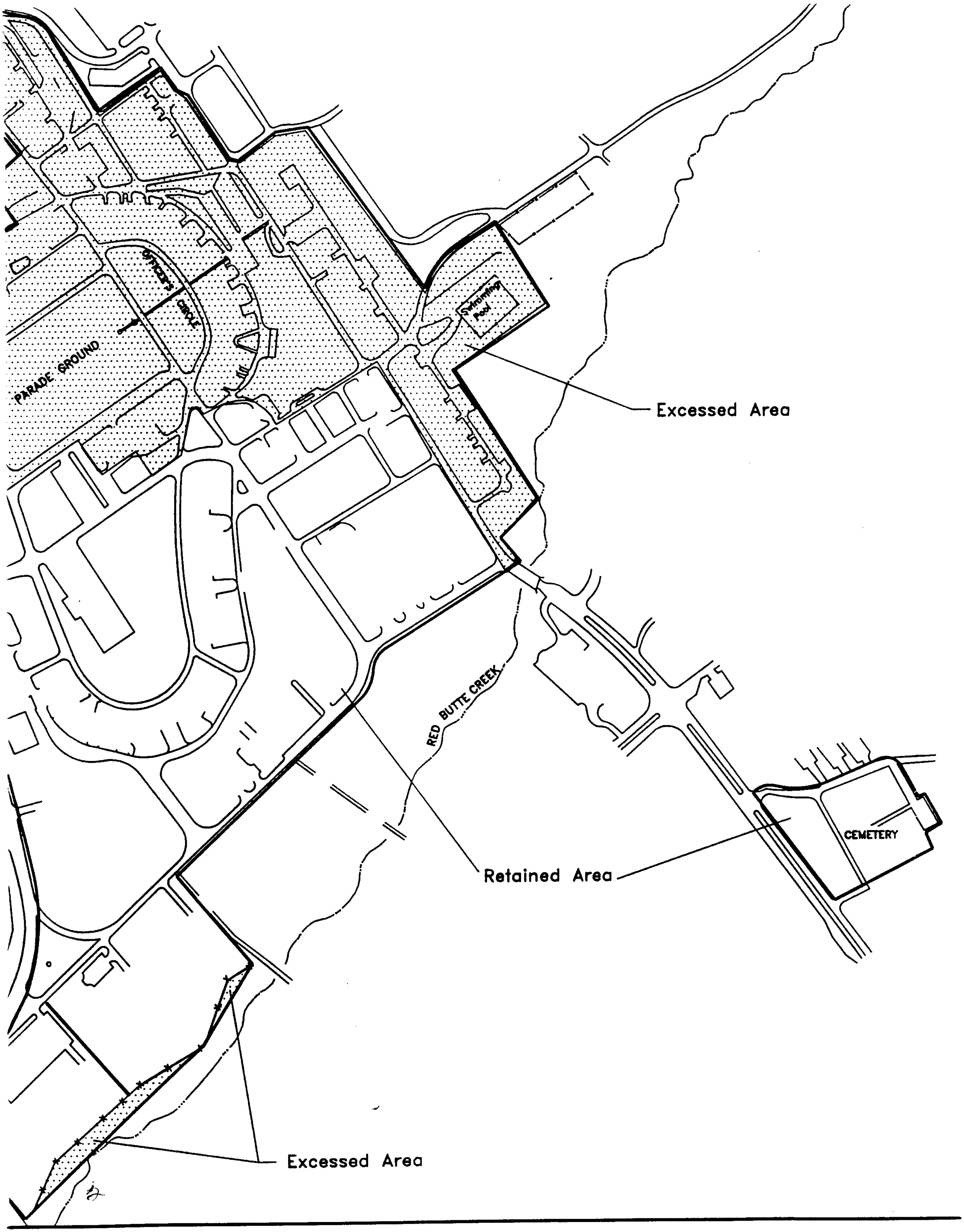
WATKINS-JOHNSON ENVIRONMENTAL, INC.
Groundwater Consulting, Environmental Engineering, Remediation Services

FORT DOUGLAS
LOCATION MAP

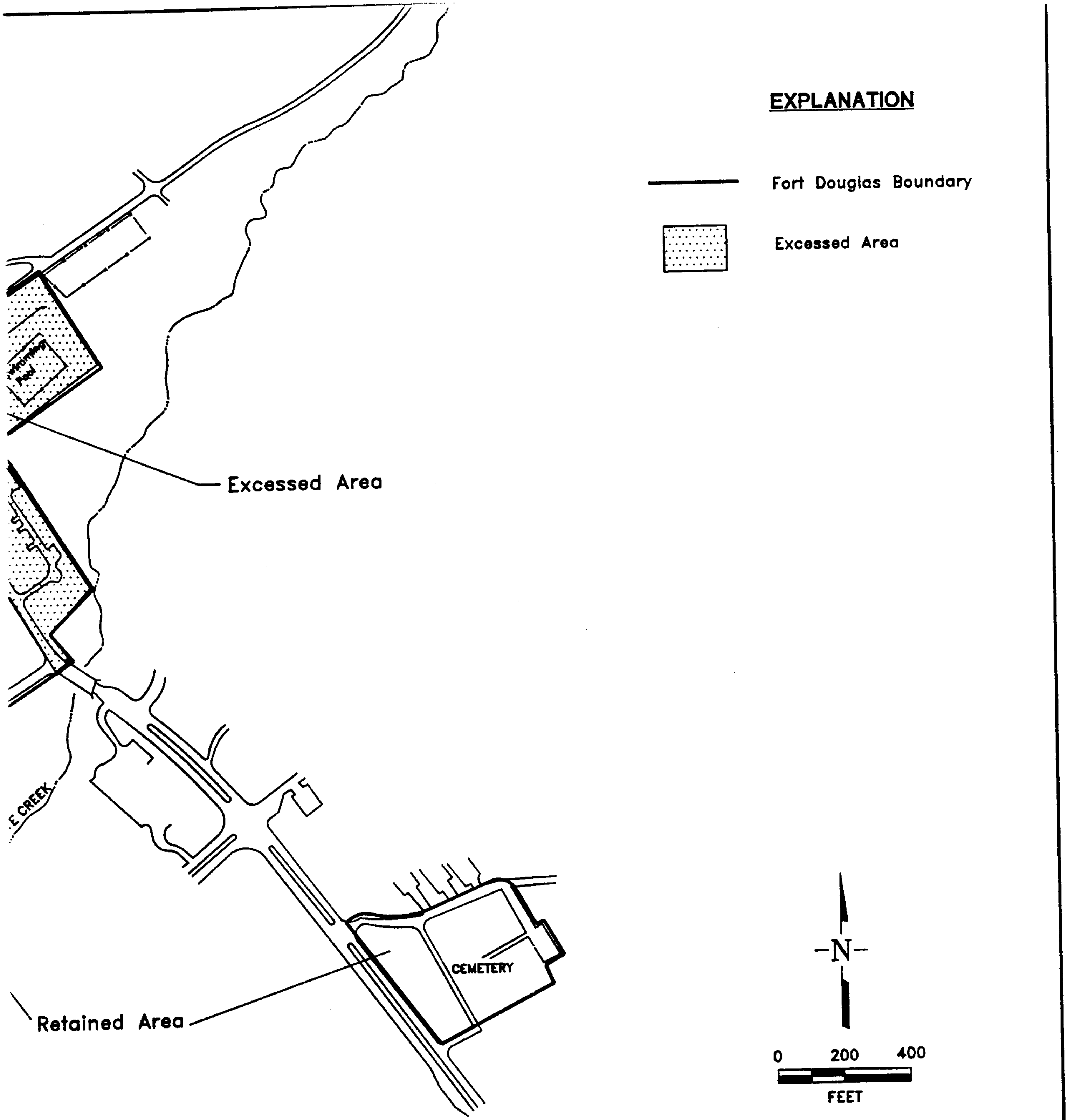
FTD25001\DV1

Date: March 1994	Figure 1-1


OFFICER'S CIRCLE
PARADE GROUND
WASATCH DRIVE
Excessed Are



PARADE GROUND
OFFICER'S
CIRCLE
Swimming Pool
Excessed Area
RED BUTTE CREEK
Retained Area
CEMETERY
Excessed Area



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SITE PLAN
FORT DOUGLAS

FTD25002\DV3

Date: March 1994

Figure 1-2

3

were presented in a separate document, the Asbestos Survey Results report (RLSA, 1991d). Based on recommendations contained in the Asbestos Survey Results report, Fort Carson conducted limited remedial activities in some of the excessed structures. These activities are summarized in Appendix C.

1.2 SCOPE

The EI and associated field work were conducted in accordance with the Fort Douglas work plan package, consisting of the Technical Plan (RLSA, 1991b), which includes the Sampling and Analysis Plan (SAP) and the Quality Assurance Project Plan (QAPP), and the Health and Safety Plan (HASP) (RLSA, 1991c). These plans were developed from results of previous investigations at Fort Douglas and provided technical guidance, sampling rationale, measures to ensure the quality of collected data, and procedures to minimize risks to human health during the field program.

1.3 SITE HISTORY

Fort Douglas was established as Camp Douglas on October 26, 1862, near Salt Lake City, Utah, primarily to guard the Overland Mail route and protect the lines of communication that linked the East and West Coasts. In addition, the presence of the camp served to quell any opposition to the federal government from the Mormon settlers. The camp was officially redesignated as Fort Douglas in 1878. In the first 50 years of the 20th century, Fort Douglas was used to garrison troops, house prisoners-of-war, and serve as headquarters for military units.

Original site boundaries included approximately 2,560 acres. Additional land acquisitions occurred primarily between 1867 and 1909 when Fort Douglas reached a maximum size of approximately 7,900 acres.

The first structures at Fort Douglas were hastily constructed primarily of logs or adobe. In the 1870s, most of the original buildings were replaced with buildings constructed of locally quarried red sandstone. Many of these buildings remain intact today. Additional building programs were implemented primarily between 1904 and 1910, from 1928 through the 1930s, and in 1941.

In 1948, activities at Fort Douglas were curtailed to the point that the United States Government decided to turn over a large portion of Fort Douglas to the War Assets Administration. Since that time, Fort

Douglas has been used as headquarters for Reserve and National Guard units and a support detachment for military activities in the region. Prior to closure of the post as an active duty fort on November 5, 1991, the acreage of Fort Douglas was approximately 119 acres. Excessed properties have been transferred primarily to other government agencies and the University of Utah. Currently, 68 acres, including the four-acre post cemetery, are to be retained by the federal government.

1.4 REGULATORY FRAMEWORK

The environmental investigations in support of the Fort Douglas closure are being managed by USAEC under the Base Closure Program. As required, the EI/AA is being conducted in accordance with the requirements of the National Oil and Hazardous Substance Pollution Contingency Plan (NCP) and the National Environmental Policy Act (NEPA) and is structured according to guidelines provided by the United States Environmental Protection Agency (USEPA) and USAEC.

The closure and transfer of the property must be conducted in accordance with the provisions of Section 120(h), "Federal Facilities, Property Transferred by Federal Agencies" of the Comprehensive Environmental Response, Compensation and Liability Act (CERCLA), as amended by the Superfund Amendments and Reauthorization Act (SARA). This section stipulates that the transfer of federal properties depends on the evaluation of hazardous substances which are known or suspected to be present at the site. It also requires that all remedial action necessary to protect human health and the environment with respect to any such substance remaining on the property has been taken before the date of such transfer.

Two acts signed into law by Congress and the President, Public Law (PL) 101-510 and PL 101-519, specify that all rights, titles, and interests in the excessed Fort Douglas property be conveyed to the University of Utah upon the closure of Fort Douglas. These acts also stipulated that the conveyance be made within one year of enactment, which was November 5, 1990. In accordance with these acts, the property was conveyed to the University of Utah. However, the EI/AA and potential environmental remediation work were not completed by the required November 5, 1991 transfer date. The memorandum of agreement between the Secretary of the Army, and the University of Utah, State of Utah, and the Utah State Historical Preservation Office states that the Army "...agrees to perform all remedial action and cleanup the areas identified pursuant to the preliminary assessment (PA) and environmental investigation/alternatives analysis (EI/AA)."

2.0 SITE BACKGROUND

The site background of Fort Douglas has been discussed in several previous reports directed by the Army (Environmental Science and Engineering (ESE), 1983; Weston, 1988; Weston, 1989; Dames and Moore, 1991). Underground storage tanks (USTs) at the facility also have been investigated (ICF, 1991; Westech, 1991). The following sections present a summary of the physical setting of the site, a physical description of the facility, and findings of previous site investigations.

2.1 PHYSICAL SETTING

Fort Douglas is located on the western slope of the Wasatch Mountains approximately 3 miles east of downtown Salt Lake City, in Salt Lake County, Utah. It is on the eastern edge of the Basin and Range Province and Great Basin sub-Province. Prior to excessing, the boundaries of Fort Douglas included 119 acres. Four of these acres consist of a cemetery located less than a mile southeast of the main installation (Figure 2-1).

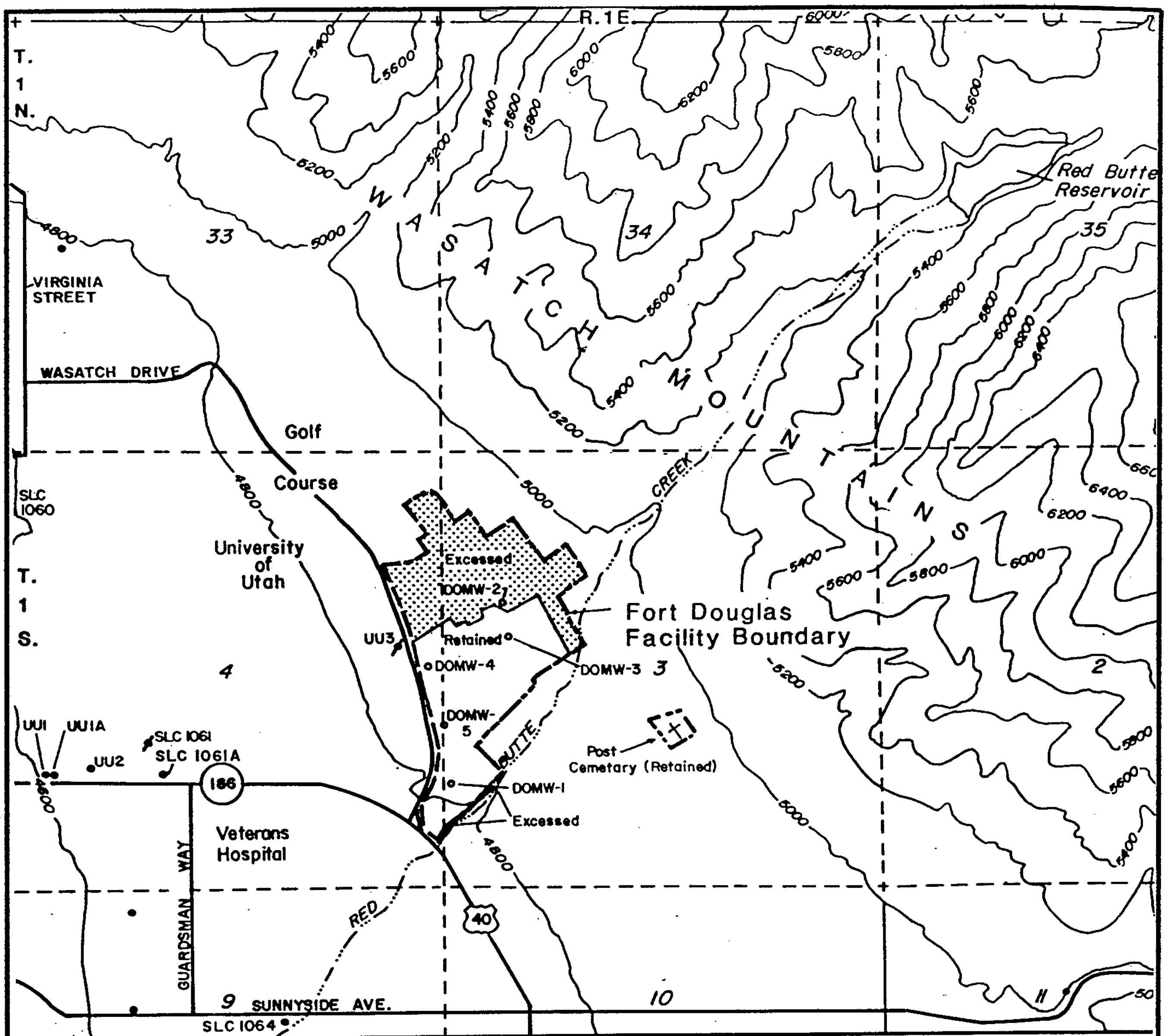
The elevation of Fort Douglas ranges from approximately 4,800 ft above sea level to 4,960 ft above sea level (Figure 2-1). The topography of the site dips gently to the west, toward the Great Salt Lake. To the east of Fort Douglas, the surface rises steeply on the flanks of the Wasatch Mountains.

2.1.1 CLIMATE

Salt Lake City has a semi-arid intermountain climate with well-defined seasons. The climate is influenced by the altitude, the Wasatch and Oquirrh Mountains, and the Great Salt Lake (Figure 1-1). The annual precipitation is 15.31 in., and the majority of the precipitation falls during March, April, and May. Temperatures are moderated by the Great Salt Lake, which never freezes due to high salt content. Average monthly temperatures range from 28.6°F in January to 77.5°F in July. The prevailing winds are from the south-southeast, and annual average wind speeds are approximately 9 miles per hour.

2.1.2 LAND USE

Fort Douglas is located on the edge of the metropolitan area of Salt Lake City. It is generally surrounded by lands used for various institutional purposes. The University of Utah administers most of the



EXPLANATION

Permitted Ground-Water Supply Well

Abandoned Well

Monitoring Well

SLC Salt Lake City Well

UU University of Utah Well

DOMW (Fort) Douglas Monitoring Well

Perennial Stream

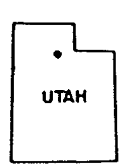
Excessed Area

Contour Interval is 200 Feet

0 1000 2000

FEET

-N-



MAP LOCATION

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FORT DOUGLAS VICINITY TOPOGRAPHIC MAP

FTD25003\DV1

Date: March 1994	Figure 2-1

properties adjoining Fort Douglas and the post cemetery (Figure 2-1). The Veterans Administration Hospital occupies an area to the south of Fort Douglas. Fort Douglas Golf Course is located north of Fort Douglas. Immediately to the east of Fort Douglas, open foothill lands lead into the Wasatch-Cache National Forest. The Forest Service, in conjunction with local governments, manages the forest, which includes a portion of the open foothill lands. The Army retains water rights and responsibilities for Red Butte Reservoir and its facilities, located within the forest. Red Butte Canyon has been designated by the Forest Service as a Research Natural Area. Research Natural Areas are relatively undisturbed areas that are closed to the public; only researchers are allowed access. Red Butte Canyon has been closed to the public since 1910, and research is conducted in this area by the University of Utah.

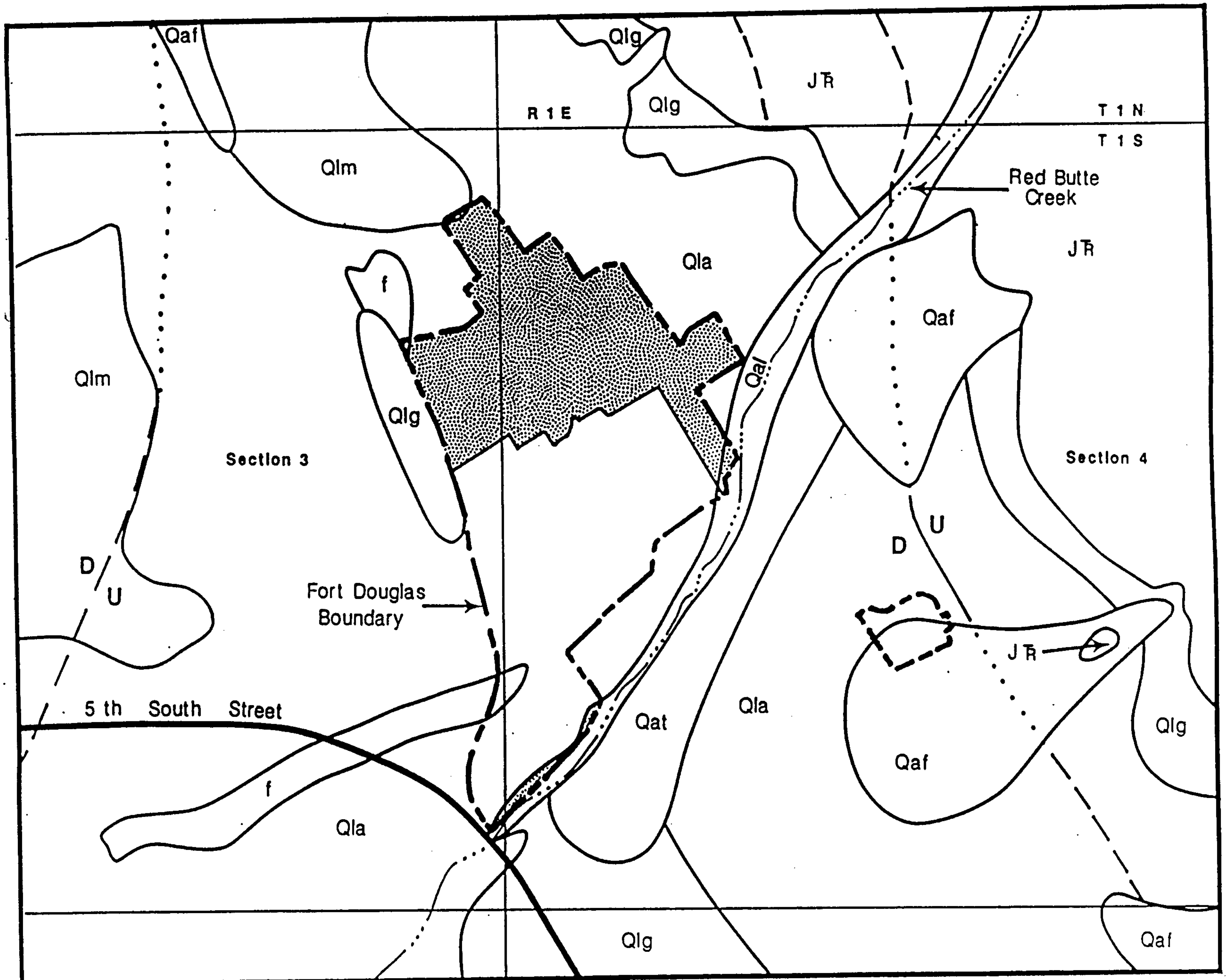
With the exception of university student housing, residential properties are not located in the vicinity of Fort Douglas. Residential communities are located approximately two-thirds of a mile to the north, west, and south of the university property.

2.1.3 Soils

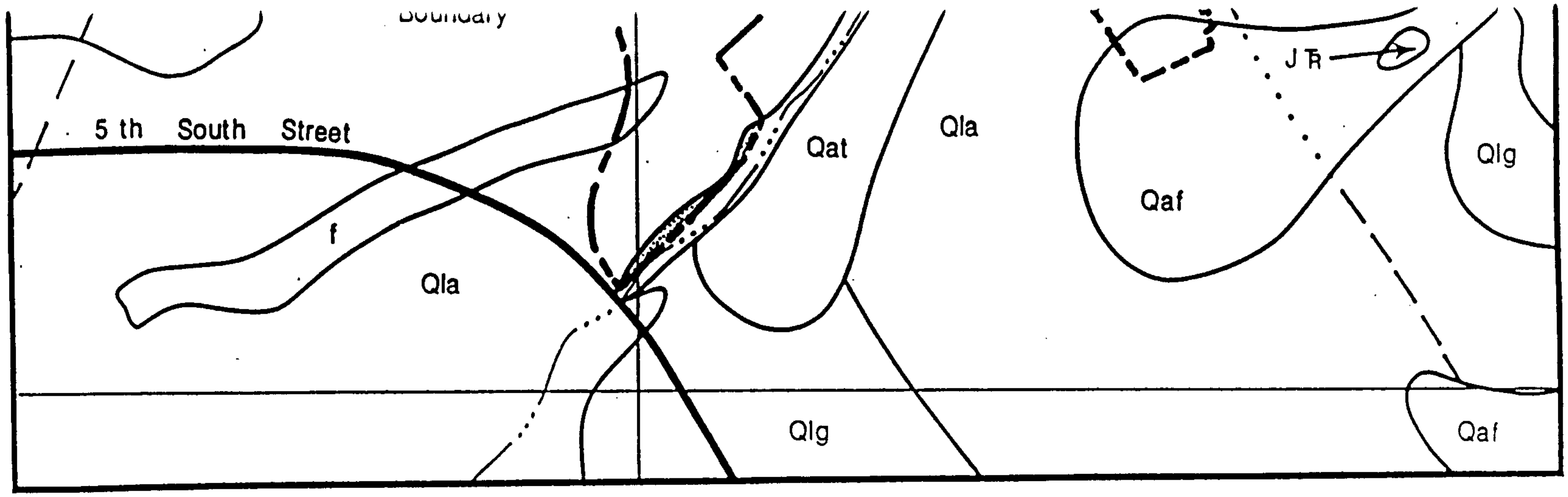
Fort Douglas soils, primarily Bingham gravelly loam, are: 1) well drained, 2) 5 or more ft deep, 3) capable of rapid water intake, and 4) characterized by moderately high permeability (United States Department of Agriculture (USDA), 1974). The Bingham soils are formed in gravelly alluvium on moderately steep slopes, and on high lake terraces and alluvial fans near the base of the Wasatch Mountains. Another soil series, Timpanogos, is found at the post cemetery and is characterized as well-drained soil formed on lake terraces. A third type of soil can be found on the sides of Red Butte Creek. This rocky, shallow soil cannot be classified by soil series but does fit a miscellaneous land type identified as stony terrace escarpments.

2.1.4 Geology

Most of Fort Douglas is underlain by unconsolidated Quaternary alluvial fan deposits, consisting of poorly sorted, clast-supported pebble and cobble gravel, locally containing boulders, in a matrix of sand and silty sand. The alluvial fan deposits are underlain by, and interfinger with, lacustrine deposits of ancient Lake Bonneville (Klauk, 1986). Lacustrine gravel and sand, deposited along the former shorelines of ancient Lake Bonneville have been mapped northeast and southwest of Fort Douglas (Figure 2-2). Lacustrine sediments deposited in quiet water, and consisting of clay and silt with a minor amount



Qaf
Qlg
Qlg
JR
R 1 E
T 1 N
T 1 S
Qlm
Red Butte
Creek
Qla
JR
f
Qaf
Qlm
Qal
Qlg
Section 3
Section 4
D
U
D
U
Fort Douglas
Boundary
JR
5 th South Street
Qat
Qla
Qlg
Qaf
f
Qla
Qlg
Qaf



EXPLANATION

Unconsolidated Material

Quaternary

f	Artificial fill - assorted materials
Qal	Flood plain alluvium - sand with cobbles, gravel, silt and clay; boulders near mountain front
Qat	Terrace alluvium - gravel and sand; cobbles and boulders near mountain front
Qaf	Alluvial fan deposits - poorly sorted cobbles, gravel, sand, silt and clay; boulders near mountain front
Qlg	Lacustrine gravel and sand - shoreline or nearshore
Qlm	Lacustrine clay, silt and sand - deep water or protected areas
Qla	Lacustrine and alluvial fan deposits - undifferentiated; lacustrine deposits may include Qlg and Qlm

Excessed Area

Contact - approximately located

D U

Fault-dashed where inferred, dotted where concealed; **U** on upthrown side, **D** on downthrown side

Source : Davis, 1983; Klauk, 1986; Personius and Scott, 1990; Scott and Shroba, 1985; Van Horn, 1969.

Unconsolidated Material

Quaternary	f	Artificial fill - assorted materials
	Qal	Flood plain alluvium - sand with cobbles, gravel, silt and clay; boulders near mountain front
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	Qlg	Lacustrine gravel and sand - shoreline or nearshore
	Qlm	Lacustrine clay, silt and sand - deep water or protected areas
	Qla	Lacustrine and alluvial fan deposits - undifferentiated; lacustrine deposits may include Qlg and Qlm

Bedrock

Jurassic/Triassic	J$\bar{R}$	Undifferentiated limestone, sandstone, shale, quartzite

Excessed Area

Contact - approximately located

D U

Fault-dashed where inferred, dotted where concealed;
U on upthrown side,
D on downthrown side

Source : Davis, 1983; Klauk, 1986;
Personius and Scott, 1990;
Scott and Shroba, 1985;
Van Horn, 1969.

-N-

0 500 1000
FEET

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FORT DOUGLAS VICINITY
GEOLOGIC MAP

FTD25004\DV1

Date: March 1994	Figure 2-2

of fine sand, locally containing medium to coarse sand and pebble gravel, have been mapped at the ground surface northwest of Fort Douglas (Personius et al., 1990). These deposits were interpreted by several authors to also be present adjacent to the southeast edge of Fort Douglas, at the University of Utah Research Park (Davis, 1983; Personius et. al., 1990; Scott and Shroba, 1985; Van Horn, 1969). However, during an investigation of the Research Park in 1986, it was determined that alluvial fan deposits covered some areas mapped previously as lacustrine deposits; therefore, Figure 2-2 includes undifferentiated lacustrine and alluvial fan deposits (Klauk, 1986). Terrace deposits of gravel and sand, with some boulders near the mountains, are south of Red Butte Creek and were deposited after a recession of ancient Lake Bonneville. Stream alluvium is present along Red Butte Creek. The thickness of the alluvium and lacustrine deposits at Fort Douglas is unknown, but is inferred to be at least 750 ft based on a lithologic log of a University of Utah Well (UU3) installed adjacent to Fort Douglas. These deposits thin to the west and unconformably overlie Lower Jurassic and older rocks, consisting primarily of sandstone, quartzite, shale, and limestone.

The eastern Salt Lake Valley area, along the front of the Wasatch Mountains, is seismically active. Earthquakes producing damage to buildings in the Salt Lake City area have occurred on average every 34 years (Klauk, 1986). A generally north-south trending fault zone marks the western extent of the Wasatch Mountains. Late Pleistocene and Holocene (100,000 to 10,000 years ago) normal faulting occurred in this zone. Normal faults trending northwest-southeast and northeast-southwest have been identified within one-half mile both east and west, respectively, of Fort Douglas (Figure 2-2).

2.1.5 SURFACE HYDROLOGY

Surface water from the Wasatch Mountains flows west to the Jordan River. The Jordan River flows northward along the west side of Salt Lake City from Utah Lake, near Provo, Utah to the Great Salt Lake. In the vicinity of Fort Douglas, surface water occurs in Red Butte Creek, which is a perennial stream flowing southwest from the Wasatch Mountains. Red Butte Creek has a relatively constant baseflow of 2.5 cubic feet per second (cfs) from October to February with peak flows occurring in the spring. Between 1963 and 1980, the mean annual flow was 4.1 cfs and maximum discharge was 60 cfs. Red Butte Creek is classified as a losing stream in the area of Fort Douglas (ICF, 1991). This is confirmed by the absence of a shallow aquifer at Fort Douglas, and, during drilling conducted by ICF, the occurrence of perched ground water only in a well near the creek.

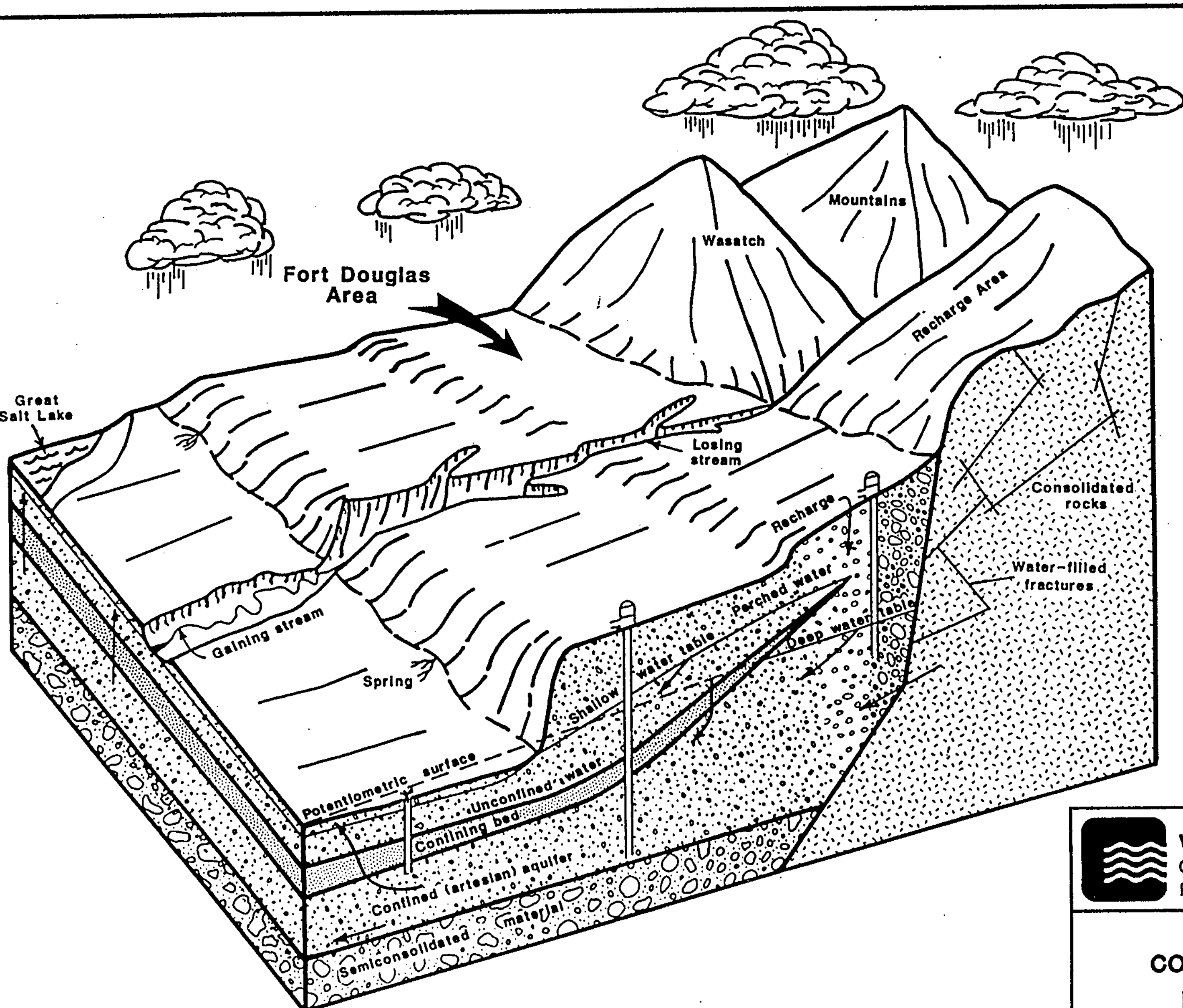
Water in Red Butte Creek is channeled from Fort Douglas through residential neighborhoods to Liberty Park Lake, approximately 2 miles southwest of Fort Douglas. Paddleboat rental is available at the lake; no fishing or swimming is permitted. During high flows, water continues to flow toward the Jordan River via tributary creeks (Emigration and Parley's).

Approximately 1.5 miles upstream of Fort Douglas, water from Red Butte Creek is stored in Red Butte Reservoir. The Army constructed the reservoir in 1930 to provide a source of potable water for the installation. Since 1986, Fort Douglas has been connected to the Salt Lake City water supply. Red Butte Creek is not used for human consumption. Downgradient of Fort Douglas, fishing is permitted in Red Butte Creek. No swimming is allowed; however, this is not strictly controlled.

The 51 excessed acres of Fort Douglas are located outside both the 100-year and 500-year flood plains of Red Butte Creek (Weston, 1989). The combined 100- and 500-year floodplains extend less than 500 ft from Red Butte Creek (Federal Engineering Management Agency (FEMA), 1983). No lakes or ponds exist in the excessed area. Storm runoff from Fort Douglas is diverted through underground storm drains to the Salt Lake City system. Surface runoff from the eastern edge of the excessed area can also enter Red Butte Creek.

2.1.6 HYDROGEOLOGY

In the Salt Lake Valley, ground water occurs in both a shallow-unconfined aquifer and an underlying confined aquifer (Seiler et al, 1984). Near the Wasatch Mountains, the confining unit is absent, and ground water is present in basin fill materials in a deep unconfined aquifer and may occur locally in perched aquifers, where saturated discontinuous lenses of sand and gravel within less permeable material lie above the water table (Price, 1985). Figure 2-3 shows a conceptual model of the hydrogeology of the area. Water supply wells in the vicinity of Fort Douglas produce water from the regional unconfined aquifer. These wells are owned by the University of Utah and the Salt Lake City Water Department (Figure 2-1). The aquifer has been logged as a thick alluvial sequence of poorly sorted coarse sand and gravel. Water levels in these wells range from 338 feet below ground surface (ft bgs) in a university well (UU3) adjacent to Fort Douglas to 105 ft bgs in Salt Lake City Well 1060, approximately 1 mile northwest of Fort Douglas. Ground-water flow in this deep regional aquifer is generally west to southwest. Recharge to the aquifer results primarily from seepage from streams and underflow in the alluvium of stream channels, such as Red Butte Creek; subsurface flow from the mountains; and seepage



EXPLANATION

← General Direction of Ground-Water Flow

Source : Hely et al., 1971

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CONCEPTUAL HYDROGEOLOGIC MODEL OF THE WASATCH FRONT AREA

FTD25005\DV1

Date: March 1994	Figure 2-3

from precipitation, irrigation ditches, and canals (Price, 1985). As the water moves from the recharge areas downgradient to discharge areas in the Salt Lake Valley, much of it becomes confined (Price, 1985). This confined aquifer is the principal source of water for domestic and industrial purposes in the Salt Lake Valley. The depth to ground water decreases to the west of Fort Douglas.

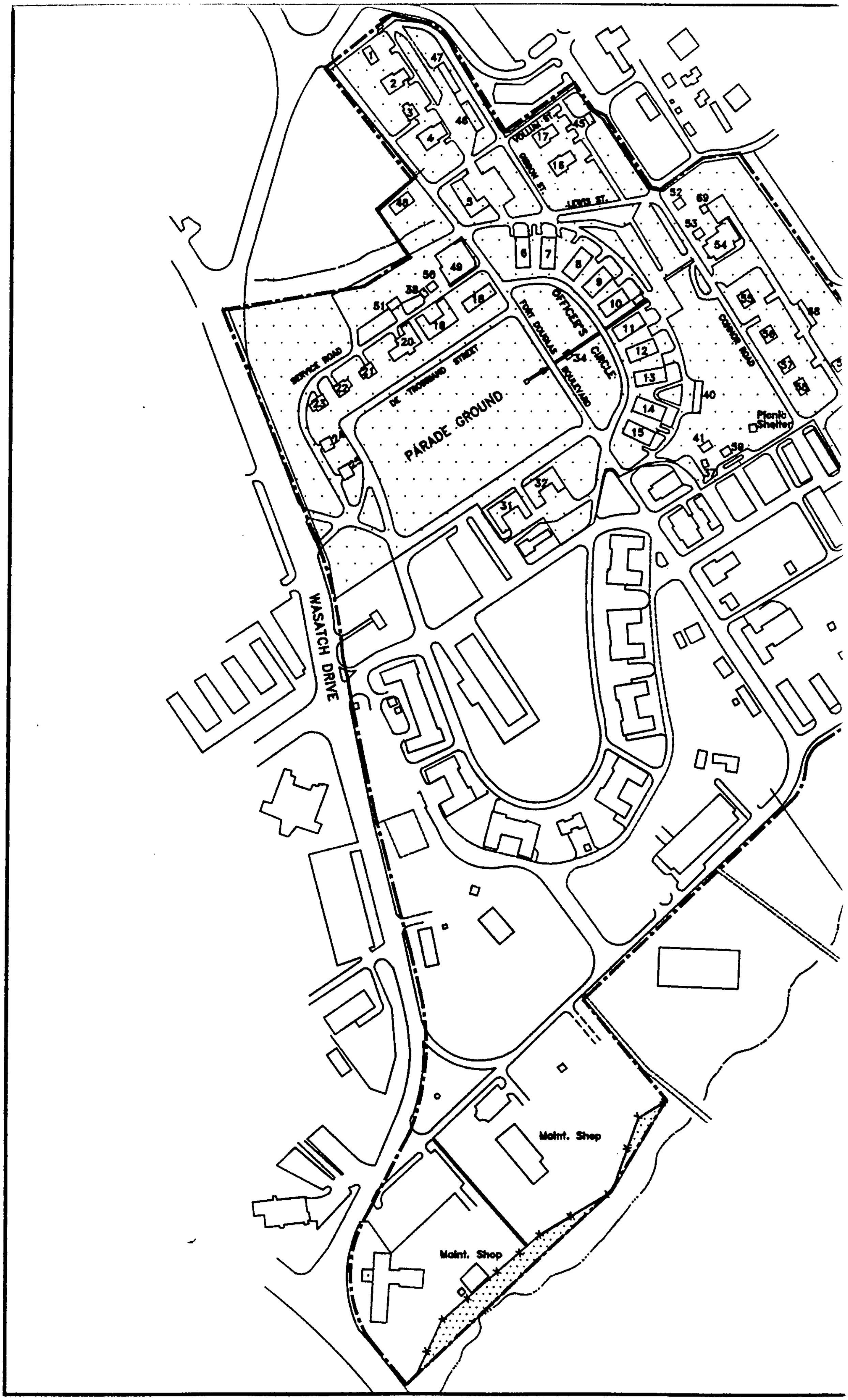
As part of a site investigation conducted for USATHAMA by ICF Technology, Incorporated (ICF), five monitoring wells were installed at Fort Douglas in November and December 1990 to investigate the potential for ground-water contamination beneath USTs located in the proposed retained area (Figure 2-1). Two of the USTs were located in the current excessed area of Fort Douglas. They were removed in August and September 1991. One of the monitoring wells (DOMW-2) is located in the excessed area. No saturated zones were penetrated during drilling of DOMW-2; however, 4 to 6 in. of water were measured approximately 25 ft bgs after completion of this well. Similar observations were noted for Well DOMW-3, located south of DOMW-2 (Figure 2-1). A saturated, silty clay unit was reached in well DOMW-1 between 17 and 20 ft bgs. This well is located approximately 400 ft from Red Butte Creek (Figure 2-1). The static perched ground-water level in DOMW-1 was 24 ft bgs. Sufficient quantities of water were not available in Wells DOMW-1, DOMW-2, and DOMW-3 to collect samples for analysis; no ground water was measured in any of the other wells.

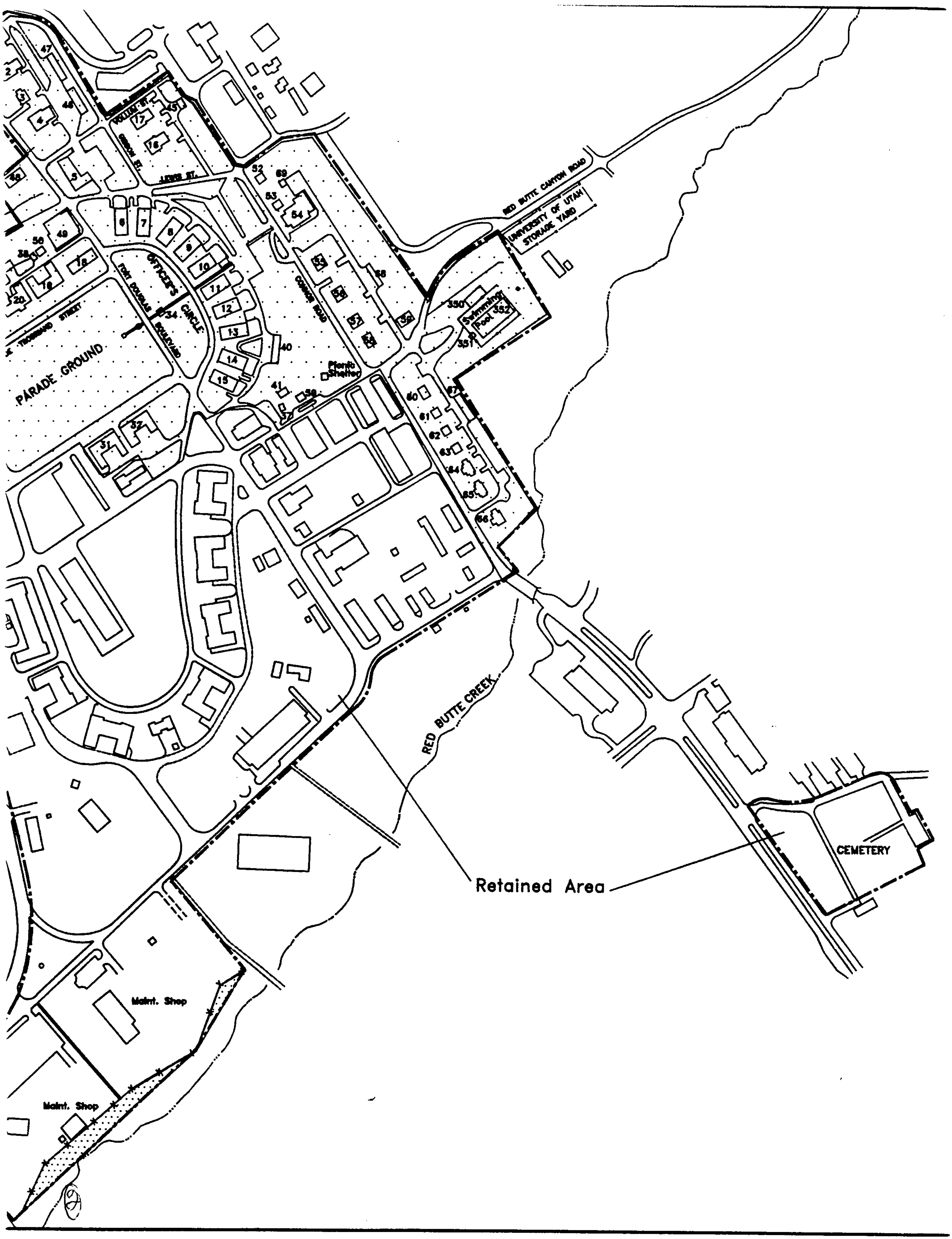
2.2 FACILITY DESCRIPTION

Prior to excessing, the approximately 119-acre installation included 117 structures, including 36 housing structures containing 61 housing units (Figure 2-4). One hundred of the structures are of permanent construction (red brick, sandstone, or concrete), in good to excellent condition, and structurally sound with an estimated life of 50 more years with proper and timely maintenance (Dames and Moore, 1991).

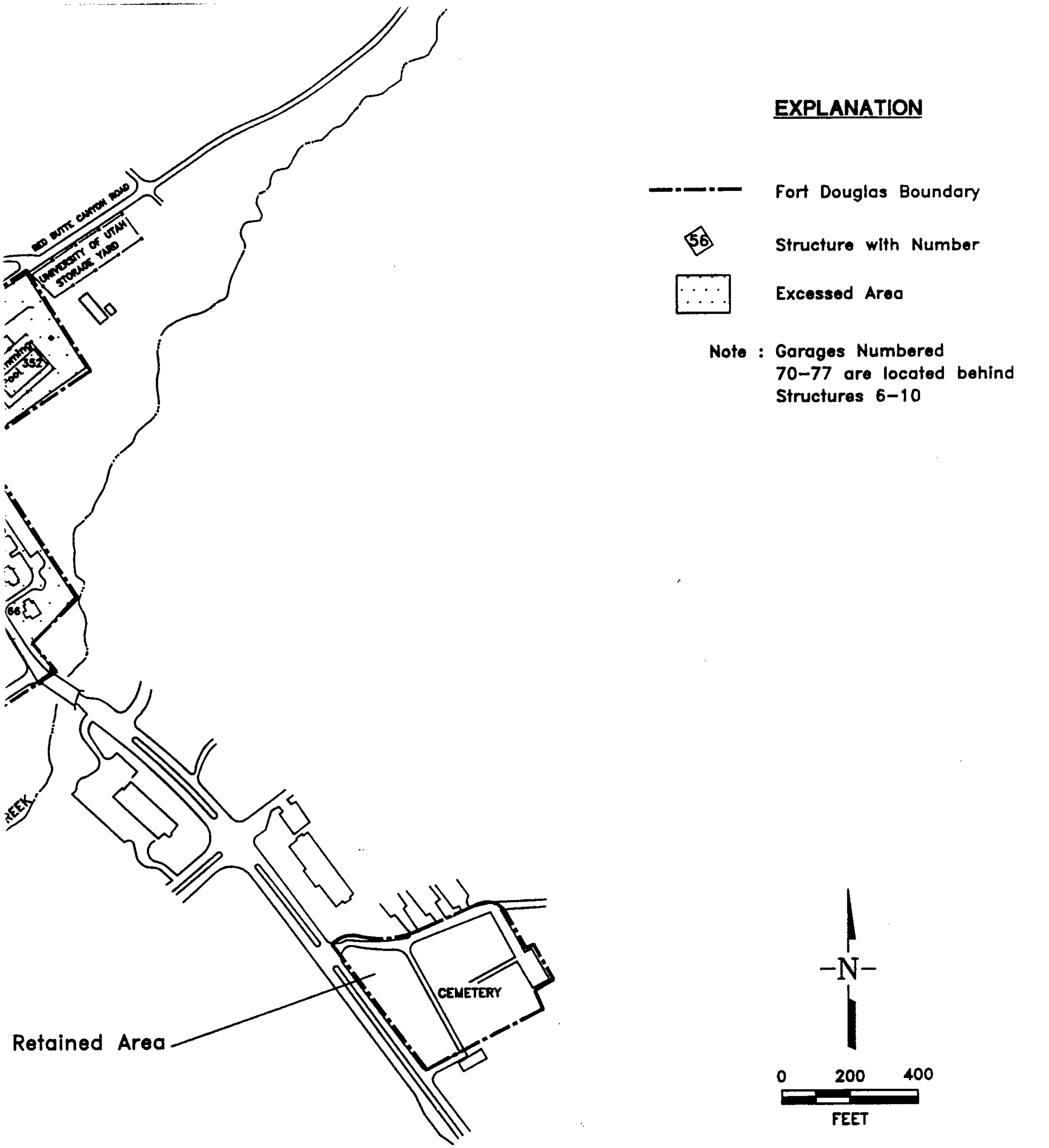
Approximately 36 acres of Fort Douglas, including the 4-acre post cemetery, have been entered in the National Register of Historic Places. In addition, an area encompassing approximately 49 acres (incorporating most of the National Register district but excluding the cemetery) has been upgraded to the status of a National Historic Landmark, and additional buildings were identified as historically significant.

The 51-acre excessed area includes 69 structures (Figure 2-4). The structures and functions prior to excessing are listed in Table 2-1. Many of the structures contain 2 or 3 housing units. Each housing unit


WASATCH DRIVE
PARADE GROUND
OFFICER'S CIRCLE
FORT DOUGLAS BOULEVARD
DE TROBRIAND STREET
SERVICE ROAD
CONNOR ROAD
LEWIS ST.
GIBBON ST.
VOLLUM ST.
Picnic Shelter
Maint. Shop
Maint. Shop



PARADE GROUND
OFFICER'S CIRCLE
FORT DOUGLAS BOULEVARD
TROSBRAND STREET
LEWIS ST.
GIBBON ST.
VOLLEY ST.
CONNOR ROAD
RED BUTTE CANYON ROAD
UNIVERSITY OF UTAH STORAGE YARD
Swimming Pool
Picnic Shelter
RED BUTTE CREEK
Retained Area
CEMETERY
Maint. Shop
Maint. Shop



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STRUCTURE LOCATIONS
FORT DOUGLAS

FTD25006\DV1

Date: March 1994	Figure 2-4

3

Table 2-1 Description of Excessed Structures at Fort Douglas (Page 1 of 2)

Structure Number	Function[1]	Date of Construction[1]
1	NCO Quarters	1910
2	NCO Quarters	1884
3	Officers Quarters	1931
4	Administrative Offices	1876
5	Administrative Offices	1904
6	Officers Quarters	1876
7	Officers Quarters	1876
8	Officers Quarters	1876
9	Officers Quarters	1876
10	Officers Quarters	1876
11	Officers Quarters	1876
12	Officers Quarters	1876
13	Officers Quarters	1876
14	Officers Quarters	1876
15	Officers Quarters	1876
16	NCO Quarters	1884
17	NCO Quarters	1884
18	Officers Quarters	1873
19	Officers Quarters	1875
20	CO Quarters	1875
21	Officers Quarters	1931
22	Officers Quarters	1931
23	Officers Quarters	1931
24	Officers Quarters	1931
25	Officers Quarters	1931
31	Administrative Offices	1875
32	Museum	1875
34	Bandstand	1912
37	Offices	1918
38	Vehicle Garage	1915
39	Latrine	1876
40	Detached Garages	1942
41	Vacant (former Gas Valve Building)	1954
45	Detached Garages	1942
46	Detached Garages	1942
47	Detached Garages	1942
48	Post Chapel	1884
49	Officers Mess	1876
50	Detached Garages	1932
51	Detached Garages	1930

[1] - Source: Dames and Moore, 1991

Table 2-1 Description of Excessed Structures at Fort Douglas (Page 2 of 2)

Structure Number	Function	Date of Construction
52	NCO Quarters	1893
53	NCO Quarters	1910
54	Community/Family Center	1933
55	Administrative Offices	1863
56	NCO Quarters	1916
57	NCO Quarters	1916
58	NCO Quarters	1930
59	NCO Quarters	1917
60	NCO Quarters	1930
61	NCO Quarters	1891
62	NCO Quarters	1891
63	NCO Quarters	1891
64	NCO Quarters	1930
65	NCO Quarters	1930
66	NCO Quarters	1933
67	Detached Garages	1930
68	Detached Garages	1931
69	Detached Garages	1917
70	Detached Garages	1972
71	Detached Garages	1972
72	Detached Garages	1972
73	Detached Garages	1972
74	Detached Garages	1972
75	Detached Garages	1972
76	Detached Garages	1972
77	Detached Garages	1972
350	Bath House	1936
351	Water Treatment Building	1942
352	Swimming Pool	Rebuilt 1988

[1] - Source: Dames and Moore, 1991

is labeled on the front of the building by the building number and by a letter (a, b, or c) designating the position of the unit (from left to right as identified when facing the front of the building). The structures were constructed primarily between 1863 and 1942. The gas valve building, now vacant, was constructed in 1954. Eight of the detached garages were built in 1972. A swimming pool that was rebuilt in 1988 was also excessed. Much of the excessed area is within the National Historic Landmark area, and most of the buildings are included in the National Register of Historical Places.

2.3 PREVIOUS INVESTIGATIONS

Environmental investigations at Fort Douglas were initiated in 1982 by the U. S. Army, when it commissioned an on-site assessment to determine past and current use of toxic and hazardous materials and the potential for migration of these substances (ESE, 1983). Another site assessment (Weston, 1988) used historical documentation and also field observations to identify locations having contained toxic or hazardous substances. An Enhanced PA and a FEIS were completed in 1989 and 1991, respectively (Weston, 1989; Dames and Moore, 1991). These reports were prepared under the Base Closure Program in preparation for the closure and realignment of Fort Douglas. Summaries of the reports are presented in the Technical Plan for Fort Douglas.

The results of the Enhanced PA and observations made during an initial EI/AA site visit served as the basis for performing EI/AA field work. This information and the sampling rationale for the EI/AA was presented in the Technical Plan (RLSA, 1991b) and also is summarized in this document. Preliminary results from a UST investigation initiated in 1990 by ICF, under the direction of Fort Carson, were reviewed prior to the EI field work and have been incorporated into the EI report.

Between August and September 1991, ten USTs were permanently closed by removal by Westech Fuel Equipment (Westech, 1991). Two of the USTs were located on the excessed area of Fort Douglas.

2.3.1 POTENTIAL CONTAMINANTS AND SOURCES

Results of the previous investigations indicated several contaminants of potential concern (COCs) and potential sources of these contaminants were located on or adjacent to excessed areas of Fort Douglas. The primary contaminants of concern in the excessed areas of Fort Douglas include polychlorinated biphenyls (PCBs), hydrocarbons, lead (in lead-based paint and/or gasoline), degreasing solvents, asbestos,

and radon. Pesticides were used only for routine applications; they are not of concern because there have been no known releases (Dames and Moore, 1991) and none were manufactured on site. In addition, only small quantities (120 gallons as reported in 1988) were stored in the retained area (Weston, 1989), and any potential release would not impact the excessed area. Potential contaminant sources to the excessed area include: 1) USTs (removed in 1991) and a wash rack/oil change/degreasing area in the Building 39 Area; 2) waste storage and maintenance areas near the southeast fence line of Fort Douglas; 3) transformers or drums in the University of Utah's storage yard adjacent to the northeast border of Fort Douglas; 4) pole-mounted transformers throughout the excessed area; and 5) buildings that may contain lead-based paint, radon, and asbestos. These are discussed by area and/or type of source in the following sections.

2.3.2 BUILDING 39

The Building 39 area (Figure 2-5) was historically used as a service station for vehicle refueling and maintenance. To support these operations, a 10,000-gallon UST was used to contain gasoline, and a 600-gallon UST possibly was used to contain oil or gasoline. Formerly, two pump sites were located to the south of Building 39, and a fill spout was visible on the east site of the building. A concrete vehicle wash rack and a concrete oil change/grease pit area with wheel guides were located to the northeast of Building 39. Drains were located on the north side of the concrete area. Additional information about the drain outlets is not available. No remnants of these operations are visible.

During the UST investigation conducted by ICF between September and December 1990, a soil gas survey was conducted, and 10 soil samples were collected from five borings in this area (Figure 2-5).

The borings were located in the vicinity of the USTs and the wash rack/oil change/degreasing area, based on results of the soil gas survey. The soil borings were drilled using an ODEX air rotary drilling system. Samples were collected using a standard 24-in. long, 2-in. diameter split spoon sampler, which was driven using a standard 140-lb hammer, falling 30 inches. In general, two analytical samples were collected from each boring. One was collected from the 5 to 10 ft interval below the bottom of the tank pit, and the other was collected near the perched ground-water interface. The samples were analyzed for total petroleum hydrocarbons (TPH) (recoverable) and benzene, toluene, ethylbenzene, and xylenes (BTEX); no detectable concentrations were present in the soil samples (Table 2-2). One monitoring well

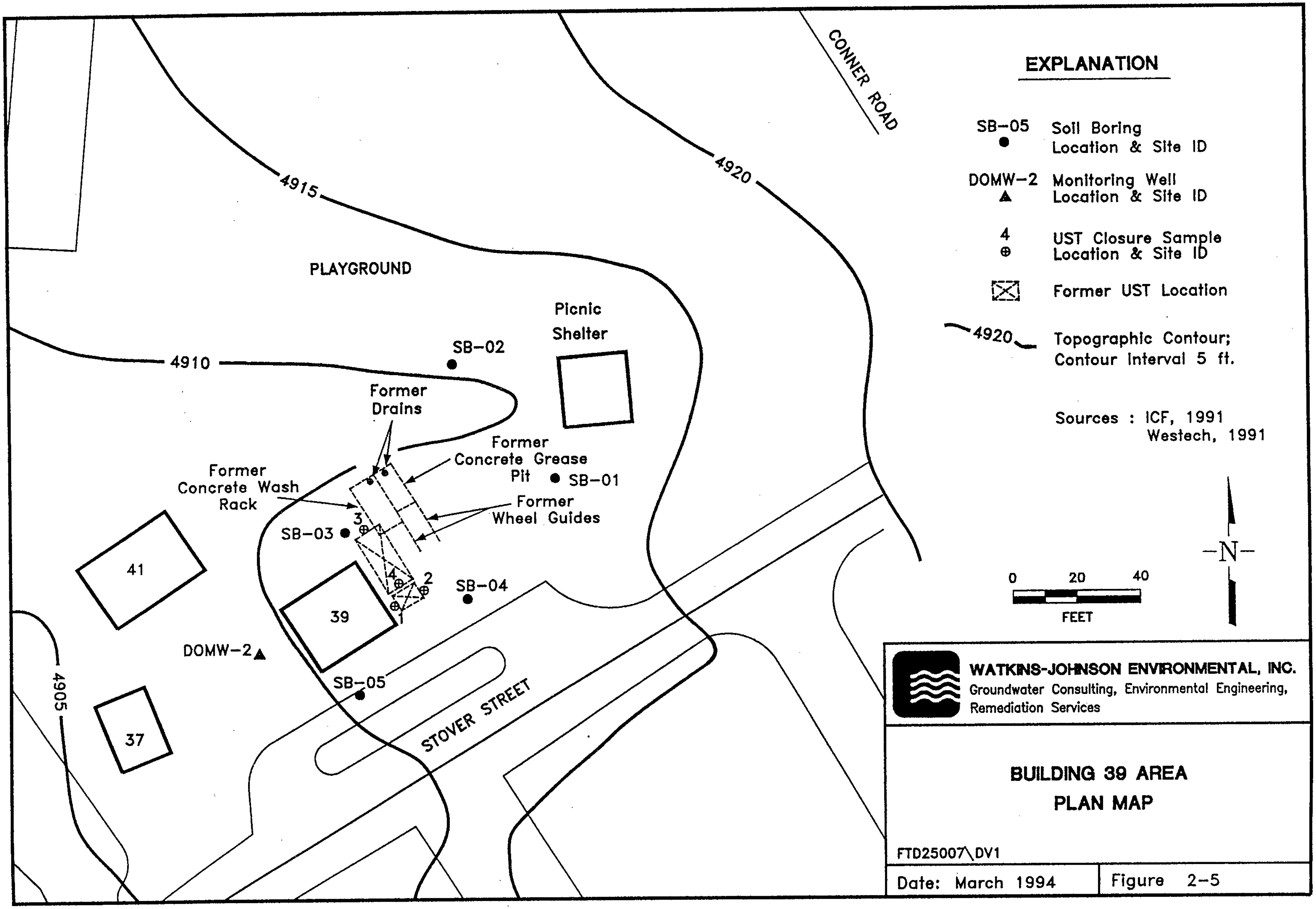

CONNER ROAD
4920
4915
4910
4905
PLAYGROUND
Picnic
Shelter
SB-02
Former
Drains
Former
Concrete Grease
Pit
SB-01
Former
Concrete Wash
Rack
Former
Wheel Guides
3
SB-03
4
2
1
SB-04
41
39
DOMW-2
SB-05
37
STOVER STREET
EXPLANATION
SB-05 Soil Boring Location & Site ID
DOMW-2 Monitoring Well Location & Site ID
4 UST Closure Sample Location & Site ID
Former UST Location
4920 Topographic Contour; Contour Interval 5 ft.
Sources : ICF, 1991
Westech, 1991
0
20
40
FEET
N
WATKINS-JOHNSON ENVIRONMENTAL, INC.
Groundwater Consulting, Environmental Engineering,
Remediation Services
BUILDING 39 AREA
PLAN MAP
FTD25007\DV1
Date: March 1994
Figure 2-5

Table 2-2 Analytical Results for Soil Samples from Building 39 UST Investigation and Closure

Site ID	Total Depth (ft-bgs)	Sample Number	Sample Depth (ft-bgs)	Benzene	Ethylbenzene	Toluene	m-Xylene	Xylene	TPH (recoverable) (418.1)[1]	TPH (GC) (8020/8015)[2]	TPH (oil and grease) (413.1)[1]
UST Site Investigation (ICF)											
SB-01	31.5	DOSS-1A	10	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
SB-01	31.5	DOSS-1B	30	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
SB-02	46.5	DOSS-2A	NI	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
SB-02	46.5	DOSS-2B	NI	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
SB-03	21.5	DOSS-3A	10	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 20	NR	NR
SB-03	21.5	DOSS-3B	NI	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 20	NR	NR
SB-04	21.5	DOSS-4A	10	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 20	NR	NR
SB-04	21.5	DOSS-4B	15	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 20	NR	NR
SB-05	25.0	DOSS-5A	10	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 20	NR	NR
SB-05	25.0	DOSS-5B	15	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 20	NR	NR
UST Closure - 600 gallon tank (Westech)											
1	NA	7107-07	ND	< 0.1	< 0.1	< 0.1	NR	< 0.1	NR	< 2.0	NR
1	NA	7639-01	ND	NR	NR	NR	NR	NR	NR	NR	< 100
2	NA	7107-08	ND	< 0.1	< 0.1	< 0.1	NR	< 0.1	NR	< 2.0	NR
2	NA	7639-02	ND	NR	NR	NR	NR	NR	NR	NR	< 100
(fill composite)		7156-6-605	NA	< 0.1	< 0.1	< 0.1	NR	< 0.1	NR	80	NR
UST Closure - 10,000 gallon tank (Westech)											
(fill composite)	NA	7478-01	NA	< 0.1	< 0.1	< 0.1	NR	< 0.1	NR	< 2.0	NR
(fill composite)	NA	7478-02	NA	< 0.1	< 0.1	< 0.1	NR	< 0.1	NR	< 2.0	NR
3	NA	7478-03	ND	< 0.1	< 0.1	< 0.1	NR	< 0.1	NR	< 2.0	NR
4	NA	7478-04	ND	< 0.1	< 0.1	< 0.1	NR	< 0.1	NR	< 2.0	NR

Units in $\mu g/g$

< = less than certified reporting limit or detection limit
TPH = total petroleum hydrocarbons
GC = gas chromatography
NR = not requested
NA = not applicable
ND = not documented (Westech, 1991); however, according to Utah guidance, collected 0 to 2 ft below the native soil.
NI = no information available

[1] - EPA, 600/4-79-020, 1983
[2] - SW-846; EPA, 1986

was installed (DOMW-2); however, it did not produce sufficient quantities of water to allow sample collection.

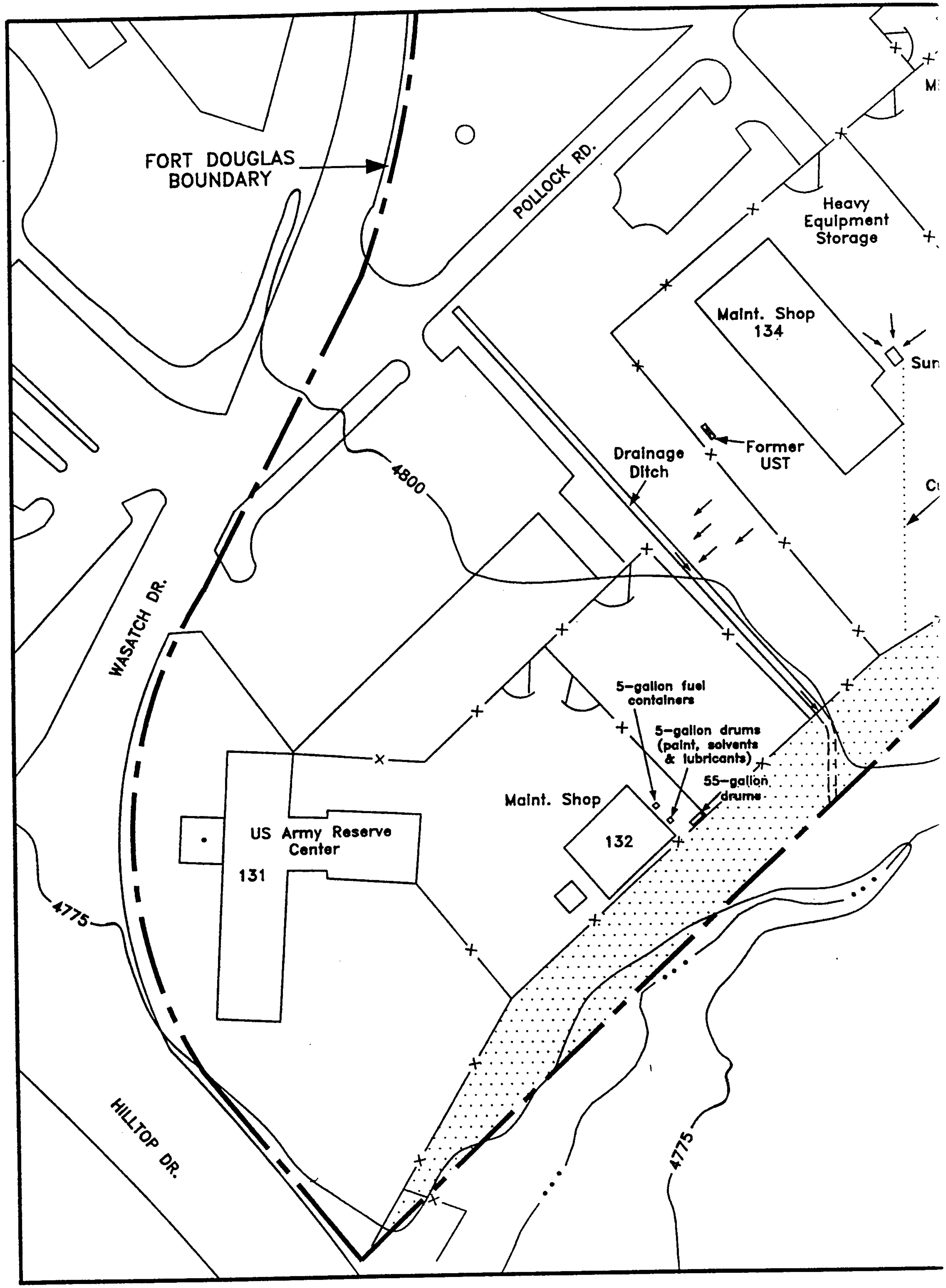
The tanks and associated piping were removed prior to the EI field work in August 1991 in accordance with procedures required by the State of Utah Department of Health. The removal and associated sampling was conducted by Westech, a Utah state-certified tank handler, tank remover and ground-water and soil sampler, under the supervision of Fort Carson. The large tank was free of holes and corrosion.

Piping in the small tank indicated it may have been used for fuel. This tank was corroded, with several holes. There was no evidence of soil contamination near either tank (Westech, 1991). Closure samples in the UST area were taken from four locations (Figure 2-5), and three composite samples of excavated fill were collected for analysis. The samples were collected from 0 to 2 ft below the native soil/backfill interface, as required by the State of Utah at the time. All samples were analyzed for BTEX and TPH (gas chromatography (GC) and oil and grease) (Table 2-2). No BTEX was detected. TPH was measured at a concentration of 80 $\mu g/g$ in a six-point composite sample of fill excavated from the 600-gallon tank area. No other TPH detections were reported. Field observations and analytical results for this site suggest hydrocarbons were not released from the tanks or associated piping (Westech, 1991). Tank closure documents are included as Appendix A.

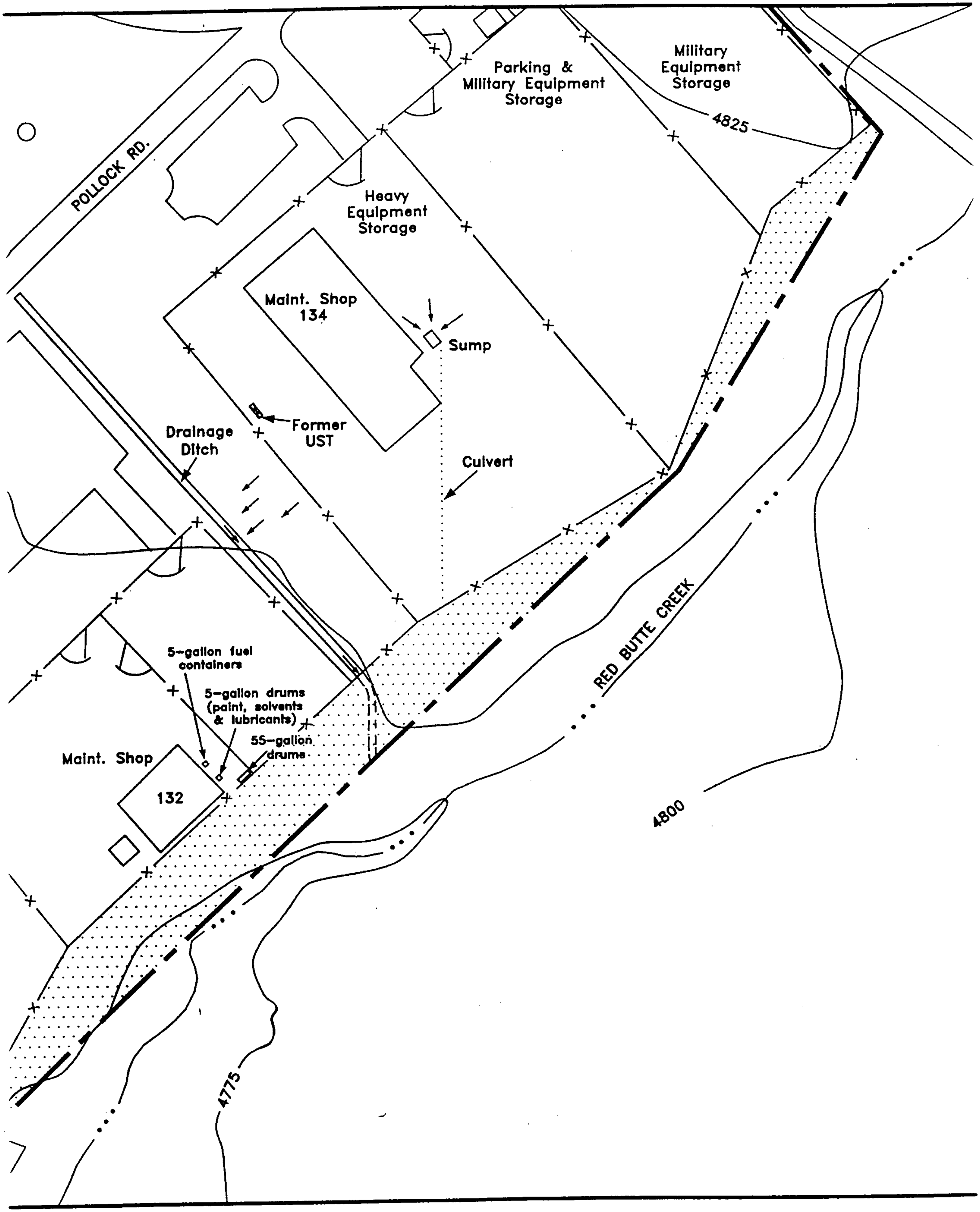
2.3.3 SOUTHEAST FENCE LINE AREA

Several maintenance and hydrocarbon storage areas are located near the southeast fence line of Fort Douglas (Figure 2-6). The 1988 site assessment identified four waste site locations (on the retained area) that were within 300 ft of the excessed area. These locations included fresh oil storage, a wash rack, and a storage area for waste oil, antifreeze, and JP-4 (jet fuel). During a site visit and interviews in June 1991, activities in the retained area were described as maintenance of heavy and light equipment and storage of heavy equipment and drums. Some of the drums were labeled to contain fuels, solvents, lubricants, and paints.

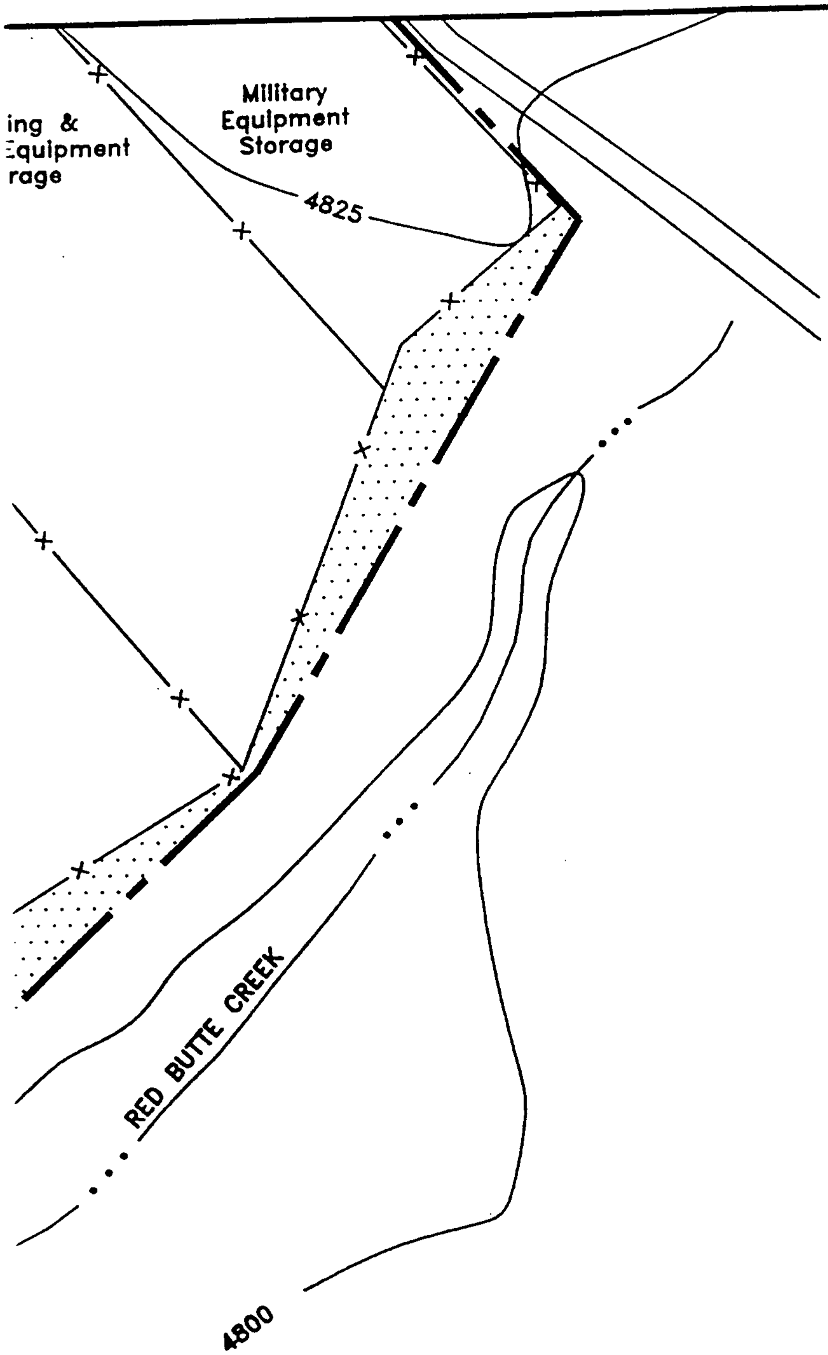
Prior to the EI, no investigations of the excessed portion of the Southeast Fence Line Area had been conducted. However, as described in the following paragraphs, the Army directed an investigation and subsequent remediation of one of the waste site locations on the retained area.



FORT DOUGLAS BOUNDARY
POLLOCK RD.
Heavy Equipment Storage
Maint. Shop 134
Former UST
Drainage Ditch
4800
WASATCH DR.
5-gallon fuel containers
5-gallon drums (paint, solvents & lubricants)
55-gallon drums
Maint. Shop
132
US Army Reserve Center
131
4775
HILLTOP DR.
4775



Parking &
Military Equipment
Storage
Military
Equipment
Storage
4825
POLLOCK RD.
Heavy
Equipment
Storage
Maint. Shop
134
Sump
Former
UST
Drainage
Ditch
Culvert
5-gallon fuel
containers
5-gallon drums
(paint, solvents
& lubricants)
55-gallon
drums
Maint. Shop
132
RED BUTTE CREEK
4800
4775



EXPLANATION

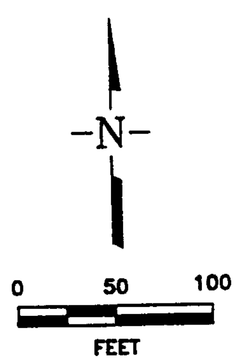
Surface Runoff Flow Direction

Fence

—4800— Topographic Contour; Contour Interval 25 ft.

Excessed Area

Concrete Drainage Ditch, dashed where approximately located



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SOUTHEAST FENCE LINE AREA
PLAN MAP

FTD25008\DV2

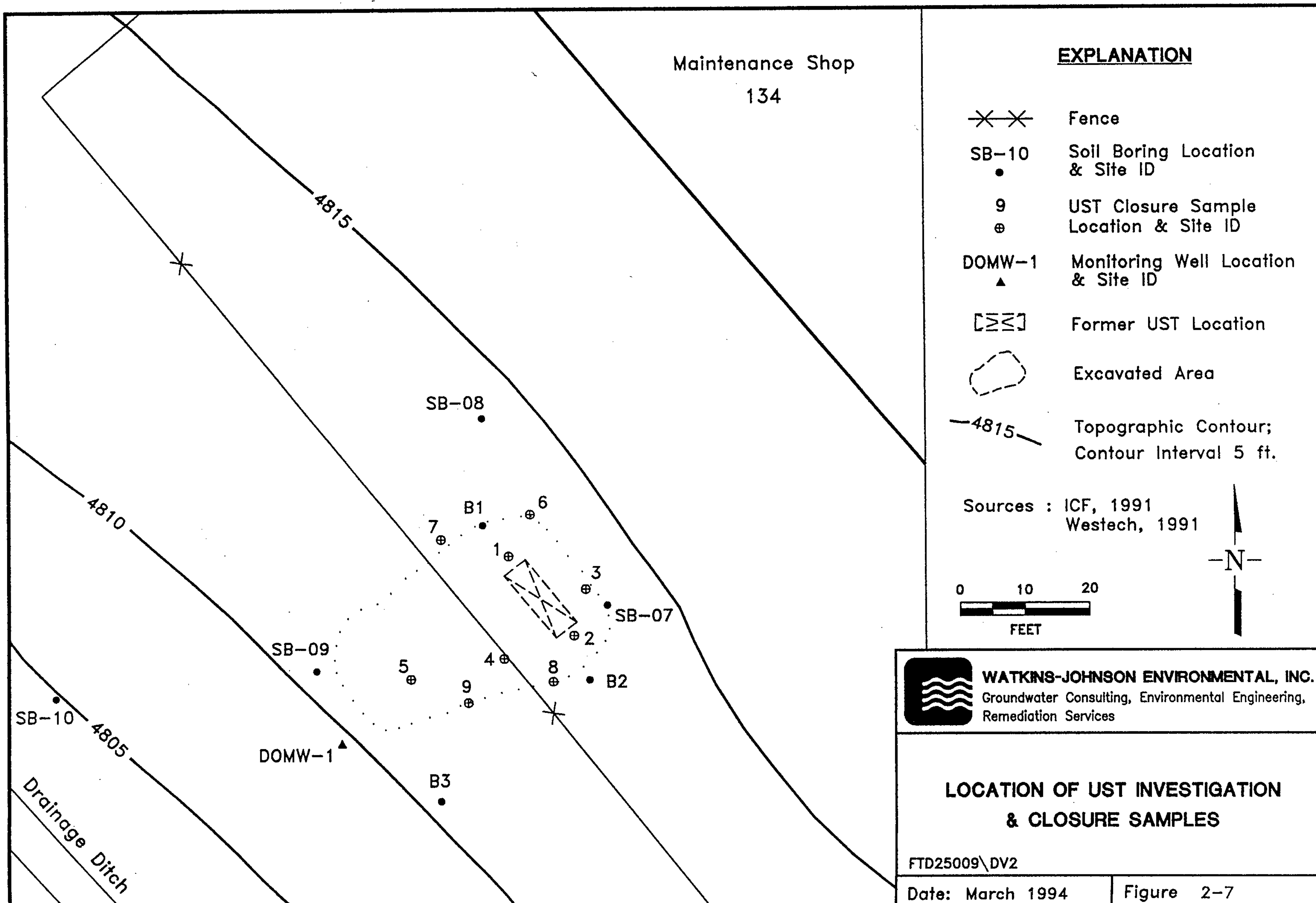
Date: March 1994	Figure 2-6

3

In December 1990, ICF conducted an investigation of a 1,000-gallon UST, formerly used for the temporary storage of waste oil as part of vehicle maintenance operations on the retained area. Waste solvents were also reportedly stored in this tank. The tank was taken out of service around 1986 after its contents were removed. This tank and another UST in the same location were reported to have leaked. During the UST investigation, a soil gas survey was conducted and results were used to locate and drill four borings (SB-07 through SB-10) and a monitoring well (DOMW-1) (Figure 2-7). Soil boring number SB-06 was not used due to changes in the planned sampling program. Drilling and sampling procedures were conducted as described in Section 2.3.2 for borings SB-01 through SB-05. Recoverable TPH (480 μg/g) were detected in a sample collected within 15 ft of the tank, at a depth corresponding to the bottom of the tank pit (Table 2-3). No TPH (recoverable) or BTEX were detected in any other soil samples. Insufficient water was present in the monitoring well; therefore, no groundwater samples were collected.

The 1,000-gallon UST, associated piping, and contaminated soil were removed in August and September 1991 by Westech. The tank was corroded and had several holes. Contaminated soil was visible at the surface and also was present beneath the tank (Westech, 1991). Two closure soil samples were collected 15 ft bgs from the north and south ends of the tank (Figure 2-7). TPH (oil and grease) concentrations were measured at 10,000 μg/g and 7,400 μg/g in these samples (Table 2-3). Fill material from the excavation was analyzed for parameters designed to determine if the soil was hazardous, and if the characteristics met the requirements of the soil reclamation company (ET Technologies). The parameters designated as necessary by ET Technologies for disposal of soil associated with waste oil included a modified priority pollutant list of volatiles and semivolatiles, including Resource Conservation and Recovery Act (RCRA) F-wastes (spent solvents); a modified Toxicity Characteristic Leaching Procedure (TCLP) list, including an expanded list of metals and a shortened list of organics; and additional chemistries, including oil and grease, ignitability, reactivity, chloride, sulfate, pH, density, and percent solids. All results of these analyses are included in Appendix A.

Additional soil was excavated to depths between 14 and 18 ft bgs as part of the subsequent over-excavation. Clean soil was reached on the east, north and west sides of the tank area; however, stained soil at the south end of the tank could not be excavated due to the presence of trees, power poles and lines, and a fence. These observations were confirmed by analytical data for the clean and stained soil samples collected from seven locations sampled during excavation (Table 2-3, Figure 2-7). Within the



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LOCATION OF UST INVESTIGATION & CLOSURE SAMPLES

FTD25009\DV2

Date: March 1994	Figure 2-7

Table 2-3 Analytical Results for Soil Samples from Building 134 UST Investigation and Closure

Site ID	Total Depth (ft-bgs)	Sample Number	Sample Depth (ft-bgs)	Benzene	Ethylbenzene	Toluene	m-Xylene	Xylene	TPH (recoverable) (418.1)[1]	TPH (GC) (8020/8015)[2]	TPH (oil and grease) (413.1)[1]
UST Site Investigation (ICF)											
SB-07	51.5	DOSS-7A	15-16.5	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	480	NR	NR
SB-07	51.5	DOSS-7B	50-51.5	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
SB-08	40.5	DOSS-8A	15-16.5	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
SB-08	40.5	DOSS-8B	38-40	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
SB-09	21.5	DOSS-9	15	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
SB-10	55.1	DOSS-10A	10	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
SB-10	55.1	DOSS-10B	45	< 0.085	< 0.160	< 0.190	< 0.260	< 0.390	< 10	NR	NR
UST Closure (Westech)											
1	NA	7107-03	15	NR	NR	NR	NR	NR	NR	NR	10,000
2	NA	7107-04	15	NR	NR	NR	NR	NR	NR	NR	7,400
Over-Excavation Confirmation (Westech)											
3	NA	7853-01	18	0.2	0.2	0.5	NR	1.4	NR	69	NR
3	NA	7853-02	18	NR	NR	NR	NR	NR	NR	NR	< 100
4	NA	7853-03	15	< 0.1	< 0.1	< 0.1	NR	0.2	NR	<2.0	NR
5	NA	7853-04	14	0.5	5.7	6.2	NR	43	NR	2,500	NR
6	NA	8445-01	6	NR	NR	NR	NR	NR	7.5	NR	NR
7	NA	8445-02	ND	< 0.1	< 0.1	< 0.1	NR	< 0.1	93	<2.0	NR
8	NA	8445-03	ND	< 0.1	< 0.1	< 0.1	NR	< 0.1	420	<2.0	NR
9	NA	8473-01	12	< 0.1	< 0.1	< 0.1	NR	< 0.1	450	69	NR
Borehole (Westech)											
B1	NI	8144-01	14-15.5	NR	NR	NR	NR	NR	< 1.0	NR	NR
B2	NI	8144-02	16.25-17.0	< 0.1	< 0.1	< 0.1	NR	< 0.1	< 1.0	<2.0	NR
B3	NI	8144-03	13.5-15.0	< 0.1	< 0.1	< 0.1	NR	< 0.1	< 1.0	<2.0	NR

Units in $\mu g/g$

- < = less than certified reporting limit or detection limit
- TPH = total petroleum hydrocarbons
- GC = gas chromatrography
- NR = not requested
- NA = not applicable
- ND = not documented; however, collected within the capillary fringe (Westech, 1991)
- NI = no information available

[1] - EPA, 600/4-79-020, 1983
[2] - SW-846; EPA, 1986

excavated area, TPH was measured by GC at a concentration of 2,500 μg/g. TPH (recoverable and GC) concentrations in soil at the south edge of the excavation were less than 500 μg/g.

Three borings (B1, B2, B3) were drilled around the perimeter of the excavation, including the south perimeter, and one sample from each boring was collected for analysis. Two samples were analyzed for BTEX and TPH (by GC and recoverable). The third sample, from boring 1 (B1), was analyzed for TPH (recoverable). No detections were reported in any of these samples (Table 2-3). Tank closure documents are included as Appendix A.

2.3.4 STORAGE YARD

A storage yard owned by the University of Utah is located off-post, adjacent to the northeast boundary of Fort Douglas (Figure 2-4). Aerial photos indicated the storage yard was constructed after 1968. Miscellaneous equipment, poorly marked drums, and transformers were observed in the storage yard during an initial EI/AA site visit. No investigations were conducted previously to determine if this area is a source of contaminant migration to Fort Douglas. Potential contaminants stored in this yard could not be definitely identified with information available prior to the EI program, but may have included PCBs and hydrocarbons.

2.3.5 TRANSFORMERS

Pole-mounted transformers are located throughout Fort Douglas. Either one or three transformers of various ages are mounted on each pole. Dielectric fluid from three of the transformers reportedly was sampled previously; PCB concentrations of 2 parts per million (ppm) were detected (Weston, 1989). The sampled transformers have not been identified. In 1985, transformers at eight locations in the excessed area were labeled as PCB-containing, based on their age; however, no sampling was performed to verify this assumption. Transformers at six other locations in the excessed area were more recently installed. Information has been obtained for one of these transformers, which is located southwest of the swimming pool adjacent to the Fort Douglas family camp. No PCBs were used in this transformer (Appendix B). No information regarding the PCB content in the dielectric fluid in any of the other transformers was available.

The Enhanced PA reported that no staining was observed in the immediate area of the transformer locations. Some of the transformers were reportedly rusted, while others were in good condition. Historical releases of potentially PCB-containing oil from the transformers have not been reported.

2.3.6 BUILDINGS

Buildings on Fort Douglas contain two types of sources for contaminants of concern: asbestos-containing materials (ACMs) and lead-based paint. In addition to asbestos and lead, another contaminant of concern is radon. An asbestos investigation was conducted prior to and independently of the EI field work; results are presented and assessed in the Final Asbestos Survey Results report released in December 1991 (RLSA, 1991d). Based on these results, Fort Carson conducted limited asbestos abatement in some of the excessed structures. This work is summarized in Appendix C.

Radon - Radon is a naturally occurring radioactive gas that is produced through the decay of uranium and thorium present in rocks and soil. Radon tends to accumulate in buildings; the highest concentrations typically are detected in basements because these areas are in contact with the ground, the primary source of radon. Concentrations fluctuate during the year; they are highest when there is decreased ventilation and indoor temperatures are significantly higher than outside temperatures, such as in the winter.

Two radon sampling programs have been conducted at Fort Douglas. Radon activity is measured in picocuries per liter of air (pCi/L). One picocurie is approximately equivalent to the decay of 2 radon atoms per minute. Results of the first program, consisting of short-term (4-day) monitoring, indicated the average concentration was 1 pCi/L, and the highest concentration was 4 pCi/L. The second program, primarily a long-term monitoring program with detectors in place for 12 months, was recently completed by Fort Carson. Analytical results are incorporated in this report.

Lead-Based Paint - Many types of house paint included lead as a major ingredient in the years prior to and through World War II. In the 1950s, other pigment materials became more popular, but lead compounds were still used in some pigments and as drying agents. The content of lead in paint was regulated beginning in 1971. Lead dust can be created from both interior and exterior paints containing lead and is an inhalation and ingestion hazard. There was no previously available information regarding lead content of paint used at Fort Douglas; however, the age of the buildings suggests that painted surfaces may include one or more coats of lead-based paint.

3.0 FIELD INVESTIGATION

The EI field program was conducted by WJE in two phases, in September and October 1991, and in July 1992. The initial sampling and analysis program (September and October 1991) was designed to address the nature, magnitude, and extent of areas of environmental concern on the excessed area of Fort Douglas. This sampling program included the collection of transformer oil samples from pole-mounted transformers, paint chip and wipe samples from buildings, and soil samples near potential sources. It also included the collection of soil samples at a location expected to represent background analyte concentrations.

The supplemental sampling and analysis program (July 1992) was initiated primarily to collect additional soil data that could be used in assessing any health risk which may impact future residents of Fort Douglas. This program consisted of the collection of surface soil samples near potential sources (as indicated by results from the initial sampling and analysis program) and also in areas expected to represent background analyte concentrations. Results of both investigative phases are presented in this report. In addition, the long-term radon sampling program conducted by Fort Carson between May 1989 and May 1990 also is incorporated in this report.

Procedures and methods specified in the EI QAPP (RLSA, 1991b) and SAP (RLSA, 1991b) for Fort Douglas were implemented to meet data quality objectives (DQOs) specified for the EI/AA program in the Technical Plan (RLSA, 1991b). Data were collected in accordance with the protocols established by the USAEC Quality Assurance Program (QAP) (USATHAMA, 1990) and the Geotechnical Requirements for Drilling, Monitor Well, Data Acquisition, and Reports (USATHAMA, 1987). Procedures described in the HASP (RLSA, 1991c) were implemented during the field program to minimize associated risks to human health. Laboratory analytical data were generated by Environmental Science and Engineering, Inc. (ESE), a USAEC-certified laboratory.

3.1 Quality Assurance and Quality Control Program and Procedures

The specific guidelines for the Quality Assurance (QA) and Quality Control (QC) Program are documented in the QAPP (RLSA, 1991b). The objectives of the QA program are accuracy, precision and reproducibility. QA is defined as the program for assuring and documenting the reliability of data. QC is the routine application of procedures for attaining and maintaining the prescribed QA standards

of performance in analysis. WJE's program, conducted according to USAEC's guidelines, outlines not only the requirements for sample analysis, but the requirements for reporting results. In addition, the data management of sample results is an integral part of the QAPP.

3.1.1 QUALITY CONTROL SAMPLES

Several procedures were implemented during the Fort Douglas EI to ensure quality data. Prior to beginning field work, samples from a water source on Fort Douglas were collected and analyzed for the entire suite of compounds planned for analysis during the EI program. The results were used to determine if the water source was suitable for decontaminating sample equipment. All sample equipment was thoroughly decontaminated by steam cleaning with approved water or rinsing with distilled water after collection of each sample to eliminate cross contamination. Results of the approved water analyses are presented in Section 4.1.

As part of the EI field QA/QC program, QC samples were collected and analyzed with the investigative samples. The QC samples included trip blanks for the soil samples, rinse blanks for soil and wipe samples, and duplicates of soil, wipe, paint chip, and transformer oil samples. In addition, the radon sampling program conducted by Fort Carson included field blanks, spikes, and duplicates. The field QC samples are used to evaluate the potential for sample cross-contamination, the effectiveness of decontamination and sampling procedures, the potential for contamination during shipping, and analytical precision. The spiked samples are used to monitor the performance of the analytical system. The types of EI field QC samples are described in the following sections. Analytical results for the QC samples and assessment of the results are presented in Section 4.1.

Trip Blanks - Trip blanks were shipped with soil samples and analyzed for volatile organics. They were prepared by the laboratory prior to sampling and accompanied the sample containers throughout sampling and shipping. Trip blank samples were not opened until they reached the laboratory. These samples were used to determine if volatile compounds in the ambient air were absorbed by the sample or if any cross contamination between samples occurred. Any analyte detected in the trip blank can be considered contamination.

Rinse Blanks - Rinse blanks for soils were collected by running distilled water through the sample collection equipment (polybutyrate tubes) after decontamination. These samples were used to determine

whether decontamination procedures had been sufficient. For wipe samples, the rinse blank was collected by moistening the wipe with distilled water. The filter and liquid were analyzed; therefore, detections would represent compounds in the filter or liquid, and indicate the reliability of the sample collection procedures.

Duplicates - Duplicate soil samples were obtained in the laboratory by dividing a sample into two portions. Duplicate samples for the other media were collected at the same time and location of the original sample and were treated the same throughout the shipping and handling process. Duplicate results were used to evaluate variability of sample results due to handling, shipping, storage, preparation, analysis, and heterogeneity of the sample. The reproducibility of results varies with the type and homogeneity of matrix analyzed.

3.1.2 LABORATORY PROCEDURES

When samples arrived at the laboratory, the Chain of Custody (C-O-C) forms that accompanied the samples from the field were checked for accuracy and corrected, if necessary, by the Project QA Officer (QAO). As samples entered the laboratory an internal laboratory C-O-C was created. This internal C-O-C accompanied the samples at all times, and analysts were required to sign in and out for the sample, assuring the security and the integrity of the sample. All samples were received and analyzed by lot. A lot is the maximum number of samples, including QC samples, that can be analyzed in a 24-hour time frame as determined by the rate-limiting step of the process. Lots were assigned to each individual method according to USAEC protocol.

Certification by USAEC is not required for analytical methods used to determine the lead concentration in paint chip and wipe samples, PCB concentration in oil, and TPH concentration in soil and water. All other analytical procedures used by the laboratory were certified by USAEC. These procedures were documented and submitted to USAEC for approval prior to commencement of analytical services. These procedures are normally based on approved USEPA methodology. Each method submitted by the laboratory to USAEC is given a unique method identification number and a unique Certified Reporting Limit (CRL). The CRL is the lowest level of an analyte in the sample being analyzed which can be quantitatively differentiated from zero with 95 percent confidence using a complete, specific analytical method and for which precision and accuracy criteria are valid. If a laboratory fails to show continued

approved performance for a method, USAEC can decertify the method due to noncompliance. The analytical methods used for the Fort Douglas EI samples are described in Appendix D.

In addition to the requirements discussed thus far, QC samples were analyzed to provide quantitative evidence that the entire method performance was comparable to or improved over the level demonstrated during certification. To comply with the USAEC QAP, it is essential that controls be initiated during, and maintained throughout, the analysis of samples. Data that were generated from the laboratory control samples were plotted on control charts, which were used to monitor day-to-day variations in routine analyses. Control samples included standard matrix method blanks and spikes, natural matrix spikes, and surrogates.

A standard matrix method blank was analyzed with each lot to monitor the performance of the analytical method. Detections in the method blank indicate the laboratory or analytical reagents are a source of sample contamination. Instances of method blank contamination were immediately investigated, and the source of contamination was eliminated, if possible. The data user was informed of method blank contamination to assess its impact on data quality (Section 4.1.2). Control charts were submitted for approval to the USAEC Chemistry Branch upon the completion of each lot. These control charts tracked the accuracy and precision of the laboratory control spikes, or the surrogate spikes. Precision and accuracy for each lot were plotted on separate control charts. The accuracy is a measurement of the recovery for the laboratory control spikes. The accuracy limits on the control chart were determined by past performance of the specific analyte. Accuracy, determined by average percent recoveries, and precision, determined by the difference between percent recoveries, were plotted for duplicate spikes on single day average control charts. Precision also was plotted as the percent difference of the laboratory control spikes on a three-point moving average.

3.2 SOIL SAMPLING

The soil sampling program was conducted to investigate potential soil contamination and identify possible sources. Soil sampling was conducted in four areas on the excessed area of Fort Douglas: 1) near the southeast fence line; 2) east of Building 39; 3) downgradient of the University of Utah's storage yard; and 4) in background locations in sodded and naturally vegetated areas. Samples were collected for chemical and physical analysis and for lithologic information.

3.2.1 FIELD METHODS

Drilling Techniques - A CME 75 drill rig equipped with a 4-1/4-in. inside diameter (ID) hollow-stem auger (HSA) was used for drilling the deep (below 5 ft bgs) soil borings. The drill crew consisted of a driller and a driller's helper from Layne Environmental. During drilling, a split-spoon sampler was advanced ahead of the drill bit so that an undisturbed sample could be collected. Polybutyrate liners were used in the core barrel to retain the sample. Lithologic samples were collected on a continuous basis. After reaching total depth, the boreholes were backfilled with grout. Before drilling at each location, all down-hole drilling and sampling equipment were decontaminated by steam cleaning with USAEC-approved water. The split-spoon sampler was cleaned with brushes and approved water between each use.

The shallow borings were drilled by WJE hydrogeologists using a hand-driven core sampler with a slide hammer and a 3-in. ID hand auger. The hand auger was used to widen the borehole after each sample had been collected. The hand auger, core sampler, and polybutyrate tubes (used for sample collection and shipment) were steam-cleaned before use at the site during the initial EI field program. The core sampler was washed with distilled water before each sample was collected, and the hand auger was cleaned with distilled water between borings.

Borehole/Sample Logging - Lithologic samples were described in detail by the WJE field hydrogeologist on field boring logs and on surface soil sample data forms (Appendix E). Information recorded included the lithologic description, Unified Soil Classification System (USCS) designation, estimated percentage of gravel, sand, and fine (silt and clay) components, moisture, consistency, and color. Drilling and sample information were also recorded.

Field Screening - Lithologic samples were screened for the presence of volatile organic compounds using a Photoionization Detector (PID) and headspace analysis. The headspace analysis was performed by placing a consistent volume of soil into a mason jar, then sealing and placing the jar in a warm location for at least 15 minutes. All samples were held at a comparable temperature. The concentration of organic compounds in the air space above the soil was measured and recorded. Headspace measurements were recorded in logbooks and on the field boring logs (Appendix E).

Sampling Procedures - Soil samples collected from borings drilled with the rig were contained in two 2.5-ft long polybutyrate liners (3.5-in. diameter) that were placed inside the split barrel. When necessary, after the sample was obtained, the tubes were cut to obtain the desired interval.

A hand-driven hammer sampler was used for collecting samples from the shallow borings and for collecting surface soil samples. Subsurface soil samples were collected in 6-in. long (2-in. diameter) polybutyrate liners that were placed inside the hand sampler. During the initial EI field program, the 0.0 to 0.5 ft bgs samples from the hand-augered borings and surface soil samples (0.0 to 0.5 ft bgs) typically were collected without a polybutyrate liner; these samples were containerized in amber glass jars. Sample collection procedures for surface soil samples were modified slightly for the supplemental EI field program. All samples were contained in polybutyrate liners. In sodded areas, the sod was removed, and the sample was collected from the 0.0 to 0.5 ft bgs interval below the root zone.

Upon retrieval of the samples, the liners were removed and sealed on both ends with plastic caps and tape, and all samples were labeled and placed in a cooler. During the supplemental EI field program, the ends of the liners were covered with teflon tape prior to capping, to inhibit possible contamination from the plastic caps. At the laboratory, soil from the ends of the polybutyrate liners was discarded, and samples were composited in the laboratory by collecting a small-diameter column of soil from the center of the liner.

3.2.2 ANALYTICAL PROGRAM

Laboratory analyses of soil samples for volatile organic compounds (VOCs), semivolatile organic compounds (SVOCs), TPH (recoverable), and metals were conducted during the EI program. In addition, analyses for cyanide were conducted on samples collected during the initial EI field program. Cyanide was not detected in any of the samples; therefore, it was removed from the target list for the supplemental EI field program. A list of target compounds for these analyses is presented in Table 3-1.

Analyses for VOCs and SVOCs were conducted to screen for a broad range of organic compounds which may have been present in the vicinity of the excessed area (Section 2.3.1). The target compound lists for these methods are based on the CERCLA Target Compound List (TCL) and on target compounds for the USEPA methods SW-846, 8240 and 8270 (USEPA, 1986). During the initial EI program, no VOC or SVOC analyses were conducted on surface soil samples. During the supplemental EI, analyses for

Table 3-1 Target Compound List

Volatile Organic Compounds

Acetone
Benzene
Bromodichloromethane
Bromoform
Bromomethane
2-Butanone
Carbon disulfide
Carbon tetrachloride
Chlorobenzene
Chloroethane
Chloroform
Chloromethane
1,1-Dichloroethane
1,2-Dichloroethane
1,1-Dichloroethene
1,2-Dichloroethene
1,2-Dichloropropane
cis-1,3-Dichloropropene
1,3-Dichloropropene
Ethylbenzene
2-Hexanone
Methylene chloride
4-Methyl-2-pentanone
Styrene
1,1,2,2-Tetrachloroethane
Tetrachloroethene
Toluene
1,1,1-Trichloroethane
1,1,2-Trichloroethane
Trichloroethene
Vinyl acetate
Vinyl chloride
Xylene

Semivolatile Organic Compounds

Acenaphthene
Acenaphthylene
Anthracene
Benzo(a)anthracene
Benzo(b)fluoranthene
Benzo(k)fluoranthene
Benzo(g,h,i)perylene
Benzo(a)pyrene
Bis(2-chloroethoxy)methane
Bis(2-chloroethyl)ether
Bis(2-chloroisopropyl)ether
Bis(2-ethylhexyl)phthalate
4-Bromophenyl phenyl ether
Butyl benzyl phthalate
Carbazole
4-Chloroaniline
2-Chloronaphthalene
4-Chloro-3-methylphenol
2-Chlorophenol
4-Chlorophenyl phenyl ether
Chrysene
Dibenz(a,h)anthracene
Dibenzofuran
Di-n-butylphthalate
1,3-Dichlorobenzene
1,4-Dichlorobenzene
1,2-Dichlorobenzene
3,3-Dichlorobenzidine
2,4-Dichlorophenol
Diethylphthalate
2,4-Dimethylphenol
Dimethylphthalate
4,6-Dinitro-2-methylphenol
2,4-Dinitrophenol
2,4-Dinitrotoluene
2,6-Dinitrotoluene
Di-n-octylphthalate
Fluoranthene
Fluorene
Hexachlorobenzene
Hexachlorobutadiene
Hexachlorocyclopentadiene
Hexachloroethane
Indeno(1,2,3-cd)pyrene
Isophorone
2-Methylnaphthalene
2-Methylphenol (o-cresol)
4-Methylphenol (p-cresol)
Naphthalene
2-Nitroaniline
3-Nitroaniline
4-Nitroaniline
Nitrobenzene
2-Nitrophenol
4-Nitrophenol
N-Nitroso-di-n-propylamine
N-Nitrosodiphenylamine
Pentachlorophenol
Phenanthrene
Phenol
Pyrene
1,2,4-Trichlorobenzene
2,4,5-Trichlorophenol
2,4,6-Trichlorophenol

PCB

Aroclor-1016
Aroclor-1221
Aroclor-1232
Aroclor-1242
Aroclor-1248
Aroclor-1254
Aroclor-1260

Metals

Aluminum
Antimony
Arsenic
Barium
Beryllium
Cadmium
Calcium
Chromium
Cobalt
Copper
Iron
Lead
Magnesium
Manganese
Mercury
Nickel
Potassium
Selenium
Silver
Sodium
Thallium
Vanadium
Zinc

Cyanide

Miscellaneous

Total Petroleum Hydrocarbons (TPH)

Note: PCBs were analyzed only in transformer oil and source water samples.

SVOCs were conducted on the surface soil samples because the initial EI indicated SVOCs, but not VOCs, may be present in the surface soil. The metals include the 23 metals on the CERCLA TCL. All methods of analysis are described in Appendix D. In addition to the samples collected for chemical analysis as described above, soil samples representative of penetrated lithologies were collected from the soil borings and retained every 5 ft or at each major change in lithology, whichever occurred first. Physical soil testing, including Atterberg Limits, sieve grain size distribution, and USCS assignment, were performed on four samples, approximately 15 percent.

Analytical results for the samples collected during the initial EI field program were accepted by USAEC; however, the usability of mercury and 2-methylnaphthalene data was qualified. Due to a laboratory coordination problem, analytical holding times for mercury were exceeded; however, preparation times were met, and the data quality is not expected to have been compromised. These data have been assigned a "L" flag code, which indicates the holding time for analysis was missed, extraction and/or preparation times were met, and data quality was not believed to be affected. In addition, the laboratory determined that an analytical standard provided by a vendor contained the compound 1-methylnaphthalene, instead of 2-methylnaphthalene, which is a target compound for the SVOC analysis. Therefore, all data for 2-methylnaphthalene associated with samples collected during the initial EI field program is considered to be data for 1-methylnaphthalene. This compound is not certified under the method, and will be flagged with an "R", indicating that it is not certified under the method, but is normally analyzed under EPA methodology. Although there is no data for 2-methylnaphthalene for the initial EI program samples, resampling was not conducted based on the close retention times and comparative toxicology of the two isomers, and because additional sample collection and analysis was conducted for the supplemental EI program.

Analytical results for samples collected during the supplemental EI field program were accepted by USAEC, with the exception of antimony data for one lot (SEY) due to low spike recovery outside of control limits. Therefore, these data may include false negative results. These data have been assigned a method code of "99" (lot UFG), which represents a noncertified method. Beryllium analyses for the same lot also had problems with low spike recovery; however, the potential bias is less than for antimony, and the results are acceptable. These data have been qualified with a "N" flag code, indicating the low spike recovery was not within control limits, and the analytical data is potentially biased.

3.2.3 CONTAMINANT SOURCES

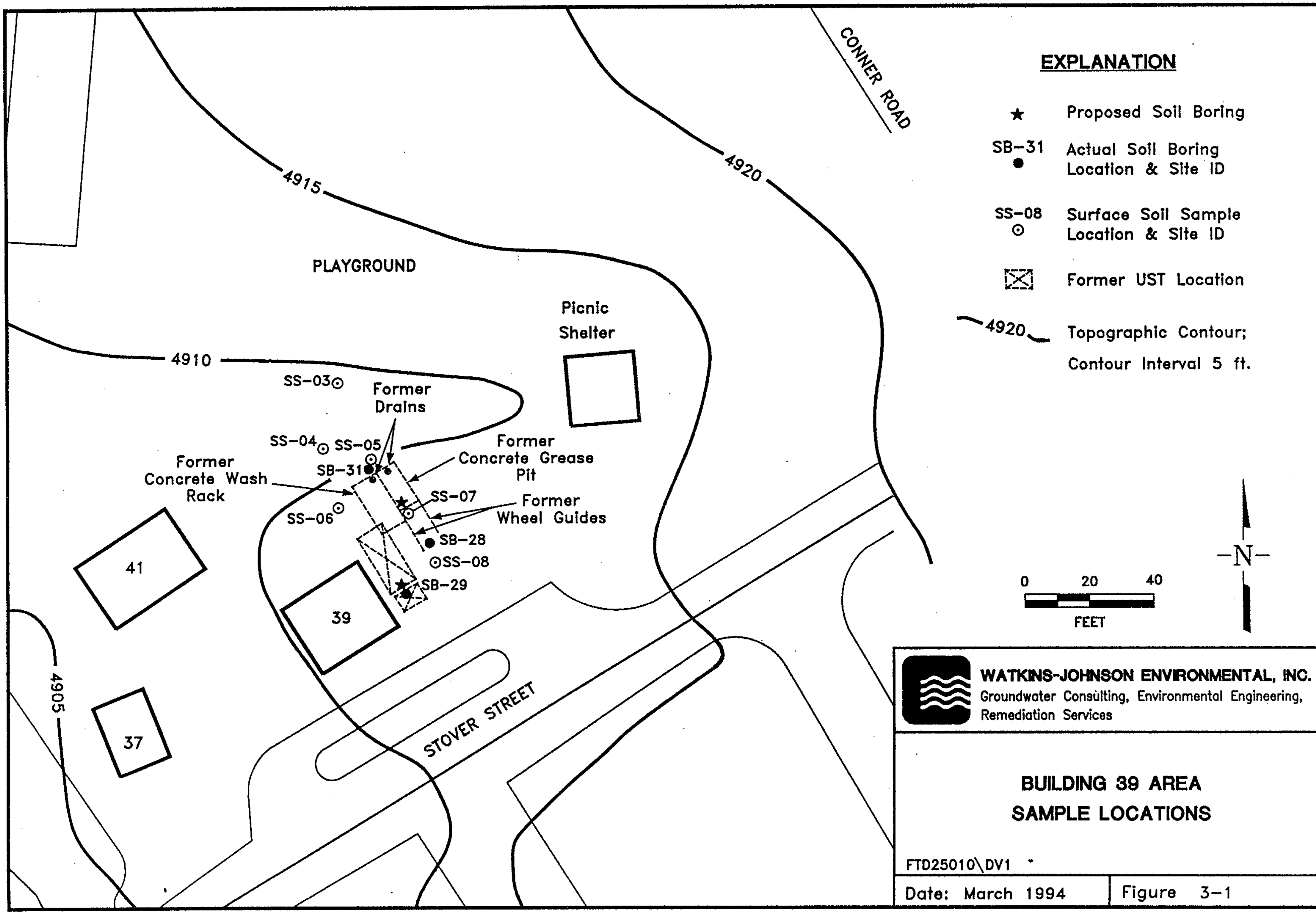
Building 39 Area - Potential leaks and spills from two underground hydrocarbon storage tanks and associated piping, and a historical vehicle wash rack/oil change/degreasing area were investigated in the soils in this area. Possible contaminants from the USTs, wash rack, and oil change/degreasing area included hydrocarbons, lead (potentially associated with leaded gasoline), and degreasers/solvents. The initial EI field program involved drilling and sampling one boring between the former locations of the USTs and two borings in the wash rack/oil change/degreasing area (Figure 3-1). Based on the results of the initial EI program, six surface-soil samples were collected in the vicinity of the wash rack/oil change/degreasing area during the supplemental EI field program.

The USTs had been removed prior to EI field work, and fill material was present to an approximate depth of 9.6 ft bgs in the vicinity of the former USTs (SB-29). Large oak trees in the area limited access of the drill rig to the wash rack/oil change/degreasing area; therefore, the boring planned in this area (SB-28) was located south of the planned location. To ensure coverage of the area, an unplanned, hand-augered boring (SB-31) was located near the north end of the wash rack/oil change/degreasing area.

Boring SB-29 was drilled to a depth of 29.5 ft bgs. Samples were composited over 5 ft intervals, between 9.7 ft bgs (below the base of the fill material) and 26.6 ft bgs, and analyzed for VOCs, SVOCs, TPH, metals, and cyanide.

At the south end of the wash rack/oil change/degreasing area, boring SB-28 was drilled to a depth of 15.2 ft bgs. At the north end, boring SB-31 was hand augered to a depth of 3.2 ft bgs. Surface soil samples (0.0 to 0.5 ft bgs) were collected from both borings and analyzed for TPH, metals, and cyanide. Subsurface soil samples (0.5 to 5.0 ft bgs in SB-28 and 0.5 to 3.2 ft bgs in SB-31) were analyzed for the same suite of compounds, as well as for VOCs and SVOCs. Surface soil samples (SS-03 through SS-08) collected as part of the supplemental EI field program were located near Borings SB-28 and SB-31 and also north and west of the wash rack/oil change/degreasing area. These six samples were analyzed for SVOCs, TPH, and metals.

Planned and actual soil boring locations are shown on Figure 3-1. The modifications and rationale for the changes to the soil boring sampling program are summarized on Table 3-2. Surface soil sample locations for the supplemental EI field program also are shown on Figure 3-1.



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BUILDING 39 AREA
SAMPLE LOCATIONS

FTD25010\DV1

Date: March 1994	Figure 3-1

Table 3-2 Soil Boring Sampling Program

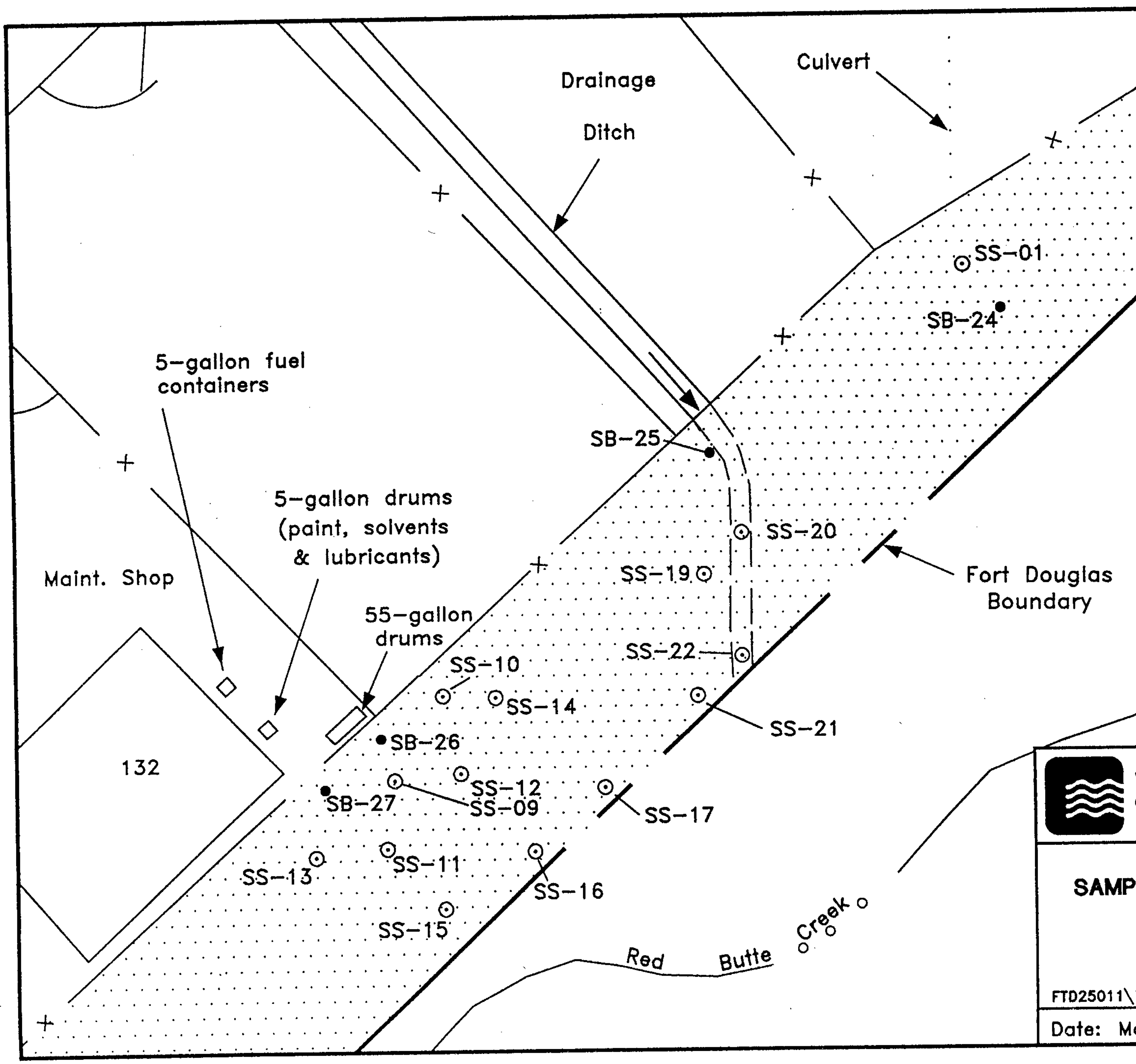
Site ID Number	Planned Total Depth (ft)	Actual Total Depth (ft)	Planned Sample Intervals (ft)	Actual Sample Intervals (ft)	Rationale for Changes
BUILDING 39 AREA					
SB-28	15	15.2	0.0-0.5, 0.5-5	0.0-0.5, 0.5-5.0	Drilled as planned; however, sample recovery was incomplete due to gravel. Location moved to avoid trees.
SB-29	30	29.5	0.0-0.5, 10-15, 15-20, 20-25, 25-30	9.7-9.9, 14.0-18.7, 19.0-21.1, 24.0-26.6	Material from 0.0 to 9.6 ft bgs was fill from UST removal. Sample recovery was incomplete due to gravel.
SB-31	-	3.2	-	0.0-0.5, 0.5-3.2	Drilled to further investigate wash rack; SB-28 could not be located in this area because of large oak trees.
SOUTHEAST FENCE LINE AREA					
SB-24	5	1.0	0.0-0.5, 0.5-5	0.0-0.5, 0.5-1.0	Auger refusal; cobbles up to 1 ft in diameter prevented deeper penetration; seven locations were attempted.
SB-25	5	4.0	0.0-0.5, 0.5-5	0.0-0.5, 0.5-4.0	Sampler lost in hole; however, it was recovered later.
SB-26	5	3.4	0.0-0.5, 0.5-5	0.0-0.5, 0.5-3.4	Auger refusal due to cobbles.
SB-27	5	3.4	0.0-0.5,0.5-5	0.0-0.5, 0.5-3.0	Auger refusal due to cobbles; lost 3.0-3.4 ft sample in hole.
SS-01	-	0.5	-	0.0-0.5	Surface soil sample was collected directly below outflow near SB-24 because SB-24 could not be drilled to a depth sufficient to assess possible vertical contaminant migration.
STORAGE YARD					
SB-30	30	29.3	0.0-0.5, 0.5-5 5-10, 15-20 25-30	0.5-5.0, 5.0-9.5, 15.0-20.0, 25.0-25.8	Drilled as planned; however, recovery was incomplete due to gravel. Location moved due to topography.
SS-02	-	0.5	-	0.0-0.5	Collected sample because SB-30 was drilled on asphalt, and no surface soil sample could be obtained.
BACKGROUND					
BKG-SB-01	30	25.2	Corresponding to samples in other borings	0.0-0.5, 9.0-13.6, 19.0-21.8	Additionally analyzed sample for VOCs and SVOCs because headspace readings were above background; Auger refusal at 25.2 ft. Location moved to avoid water, sewer, electric lines.

Southeast Fence Line Area - Potential releases and migration of contaminants from paved drum and fuel storage areas, waste oil USTs, and parking/storage lot (all on the retained area) were investigated by drilling soil borings during the initial EI field program on the excessed area at those downslope locations with the highest probability of receiving contaminated runoff. Potential contaminants included fuels, solvents, degreasers, lubricants, and paints. On the basis of data from the initial EI field program, surface soil samples were collected during the supplemental EI field program to further investigate contamination from surface runoff from the paved drum and fuel storage areas and the waste oil UST, and also to assess potential compounds associated with pieces of coal and other debris found in much of the soil in the Southeast Fence Line Area.

At the time of the field investigations, natural vegetation covered the Southeast Fence Line Area, and building materials- including rebar, concrete, barbed wire, wood, gravel, and iron pipe-, were noted scattered throughout the area. This area was not accessible by vehicle. The concrete drainage ditch south of Building 134 was visible only near the outfall, which is located at the southeast boundary of the excessed area (Figure 2-6). As measured in the excessed area, the ditch is covered by approximately 0.5 to 1.5 ft of soil. In the drum storage area near Building 132, two upright unlabeled drums, one overturned empty drum, and a dry, rust-colored stain on the pavement were observed during the initial EI field program. Several 5-gallon buckets, two of which were identified as methanol and lube oil enamel, a plastic container containing possible oil, a battery, and a drum were located on or near pallets at the northeast corner of the building. A black surface stain on the pavement was noted in the immediate vicinity of the pallets. Further to the west, beside the building, were several 5-gallon fuel containers.

During the supplemental EI program, three used (vehicle) oil filters were in the excessed area downslope from Building 132. In addition, in the excessed area between Hilltop Drive and Building 132, pieces of porcelain and coal were mixed with soil that had been upturned by burrowing animals. In a cut bank of Red Butte Creek, large animal bones, porcelain dish fragments (including a shaving cup), a piece of a glass bottle, a rifle casing, and a layer of coal mixed with soil were observed at the ground surface and, in some areas, to an approximate depth of 3 ft bgs.

For the initial EI field program, four borings were planned to be hand augered to a depth of 5 feet. However, due to the subsurface geology in this area, the borings were augered to depths ranging from 1.0 ft bgs (SB-24) to 4.0 ft bgs (SB-25) (Figure 3-2). Surface soil samples (0 to 0.5 ft bgs) were collected from the borings and analyzed for TPH, metals, and cyanide. Subsurface soil samples were



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SAMPLE LOCATIONS IN THE CENTRAL PART OF THE SOUTHEAST FENCE LINE AREA

FTD25011\DV1

Date: March 1994

Figure 3-2

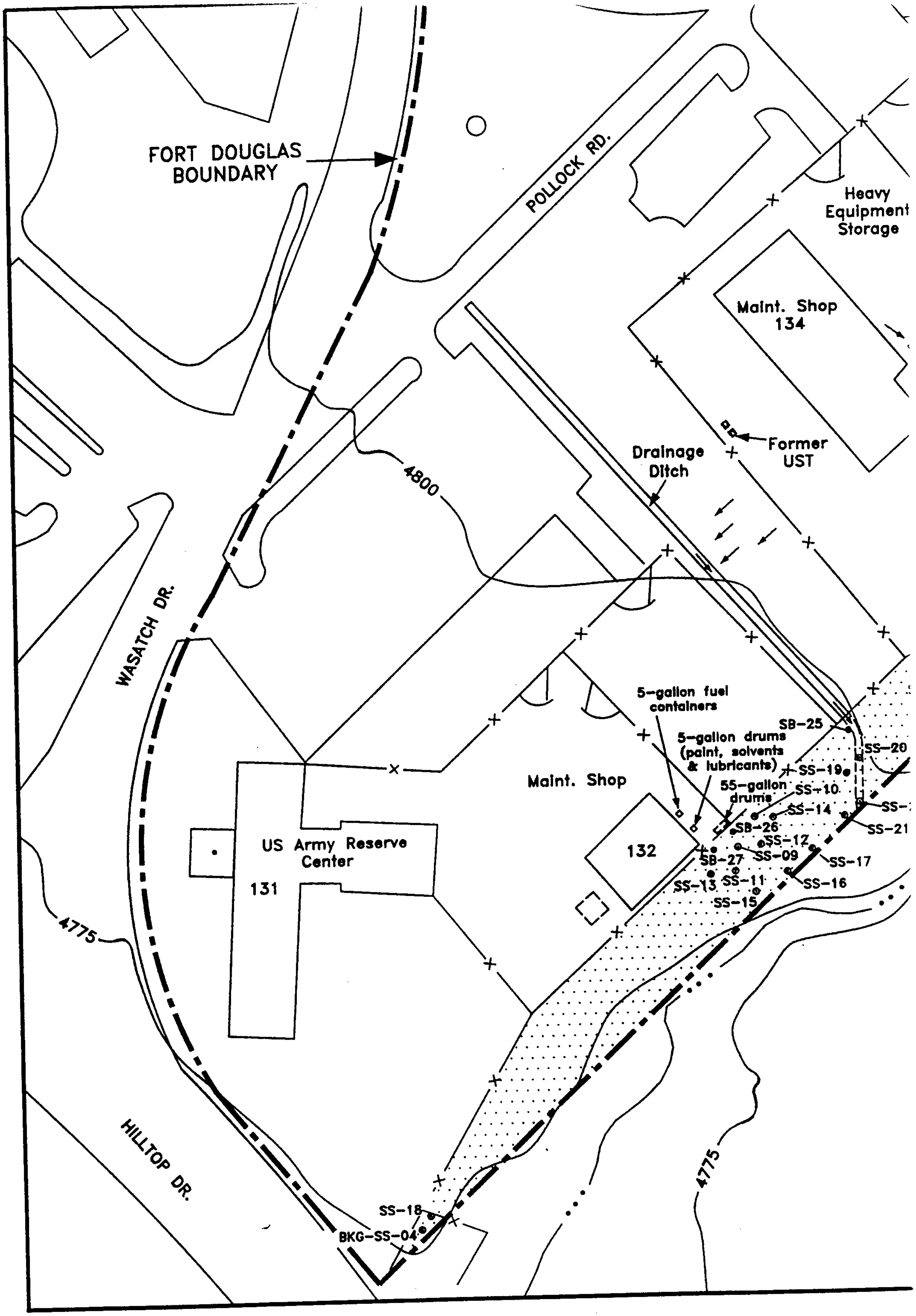
composited from 0.5 ft bgs to the total depth of each boring and analyzed for the same suite of compounds and also for VOCs and SVOCs. An unplanned, surface soil sample (SS-01) was collected directly below the culvert outlet and analyzed for TPH, metals, and cyanide because boring SB-24 could not be drilled to a depth sufficient to assess potential vertical contaminant migration, as planned. Soil boring and surface-sample locations are shown in Figure 3-2. The modifications to the soil boring sampling program and rationale for the changes are summarized in Table 3-2.

During the supplemental EI program, nine surface soil samples (SS-09 through SS-17) were collected downslope from the drum and fuel storage area near Building 132. Four surface soil samples (SS-19 through SS-22) were collected in the vicinity of the concrete drainage ditch. Two of the samples were composed of soil infilling the concrete ditch, and the other two were collected at downslope locations. An additional surface soil sample (SS-18) was collected near Hilltop Drive, on the excessed area (Figure 3-3). This location was expected to be representative of a background area; however, coal or coal-like fragments were noted in the sample. All of the samples were analyzed for SVOCs, TPH, and metals.

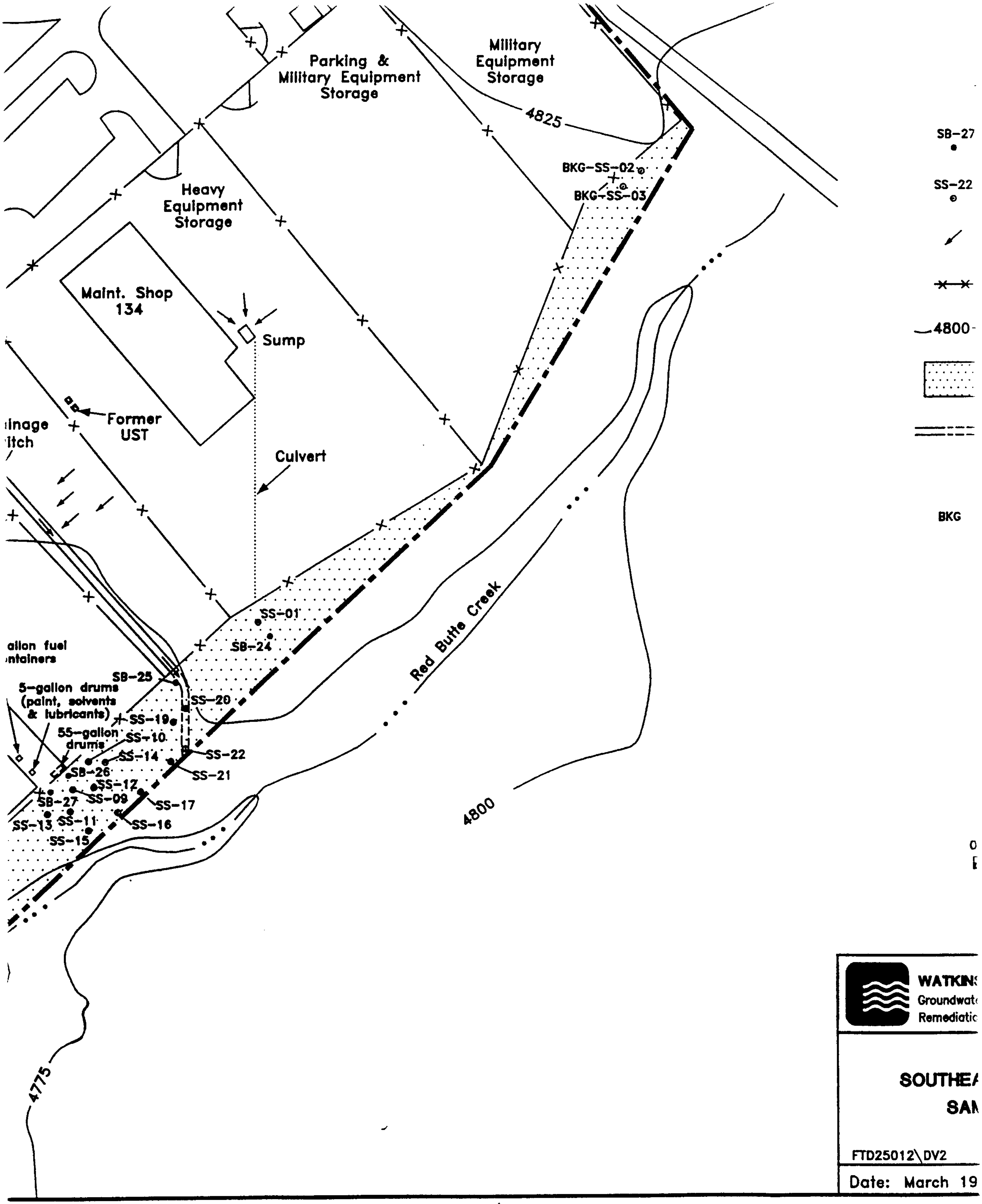
<u>Storage Yard</u> - Potential soil contamination at Fort Douglas due to possible releases in the University of Utah's storage yard was investigated during the initial EI field program by drilling a soil boring just inside the Fort Douglas property line, downslope of the storage area. Potential contaminants historically stored in this yard could not be confidently identified with available information, but previous observations indicated they may have included PCBs and hydrocarbons.

At the time of the field investigation, the storage yard was a fenced area, measuring approximately 20 by 55 feet. Approximately 40 drums, some labeled "Radioactive LSA" (low specific activity) and "hold", almost all sealed and all in good condition, were neatly stacked on pallets inside the fence. Five-gallon containers of hydraulic fluid and lubricating oil were also present. Absorbent material appeared to be scattered around the perimeter of the storage yard.

One boring (SB-30) was drilled to a depth of 29.3 ft bgs to investigate contamination that may have migrated via surface runoff and the vertical extent of potential contamination (Figure 3-4). Samples were composited over 5-ft intervals (0.5 to 5 ft bgs, 5 to 9.5 ft bgs, 15 to 20 ft bgs, and 25 to 25.8 ft bgs) and analyzed for VOCs, SVOCs, TPH, metals, and cyanide.



FORT DOUGLAS BOUNDARY
POLLOCK RD.
Heavy Equipment Storage
Maint. Shop 134
Former UST
Drainage Ditch
4800
WASATCH DR.
5-gallon fuel containers
5-gallon drums (paint, solvents & lubricants)
55-gallon drums
SB-25
SS-20
SS-19
SS-10
SS-14
SS-21
SB-26
SS-12
SS-09
SS-17
SB-27
SS-11
SS-16
SS-13
SS-15
Maint. Shop
132
US Army Reserve Center
131
4775
HILLTOP DR.
SS-18
BKG-SS-04



Parking & Military Equipment Storage
Military Equipment Storage
4825
BKG-SS-02
BKG-SS-03
Heavy Equipment Storage
Maint. Shop 134
Sump
Former UST
ılnage
ıitch
Culvert
SS-01
SB-24
allon fuel
ıntainers
SB-25
5-gallon drums (paint, solvents & lubricants)
SS-20
SS-19
55-gallon drums
SS-10
SS-14
SS-22
SS-21
SB-26
SS-12
SB-27
SS-09
SS-17
SS-13
SS-11
SS-16
SS-15
Red Butte Creek
4800
4775
SB-27
SS-22
4800
BKG

WATKIN
Groundwat
Remediatic
SOUTHE
SA
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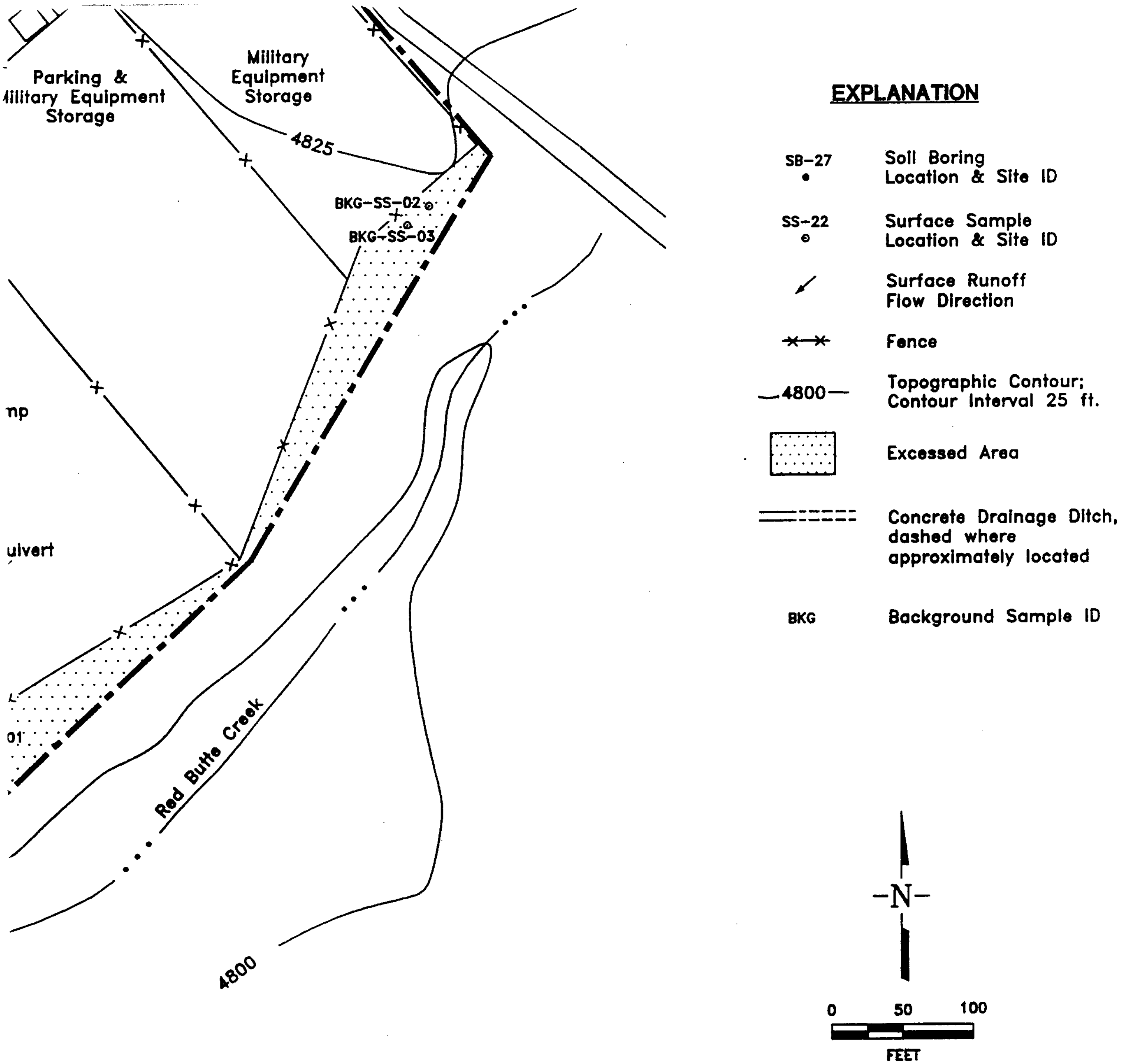

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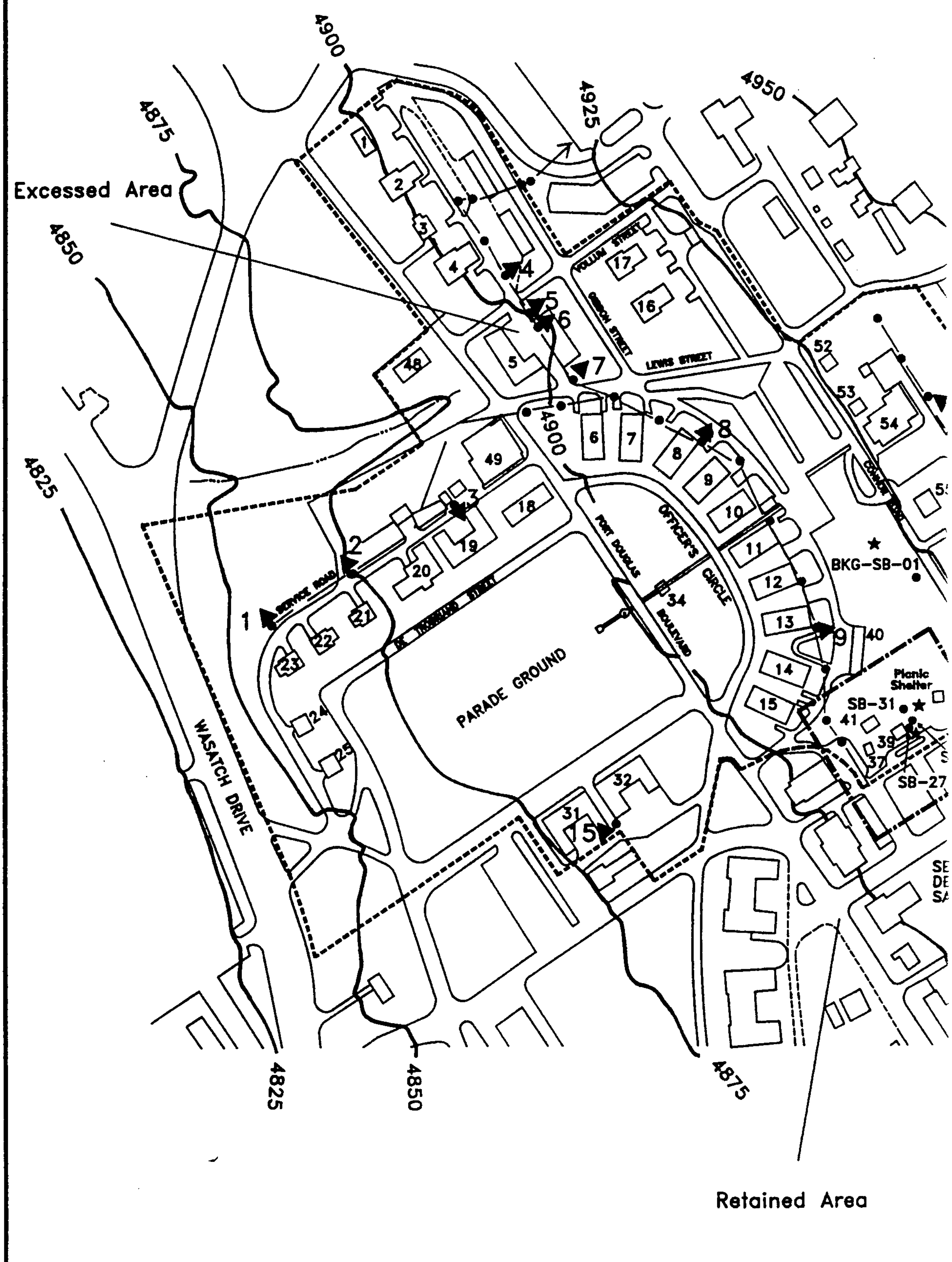
SOUTHEAST FENCE LINE AREA
SAMPLE LOCATIONS

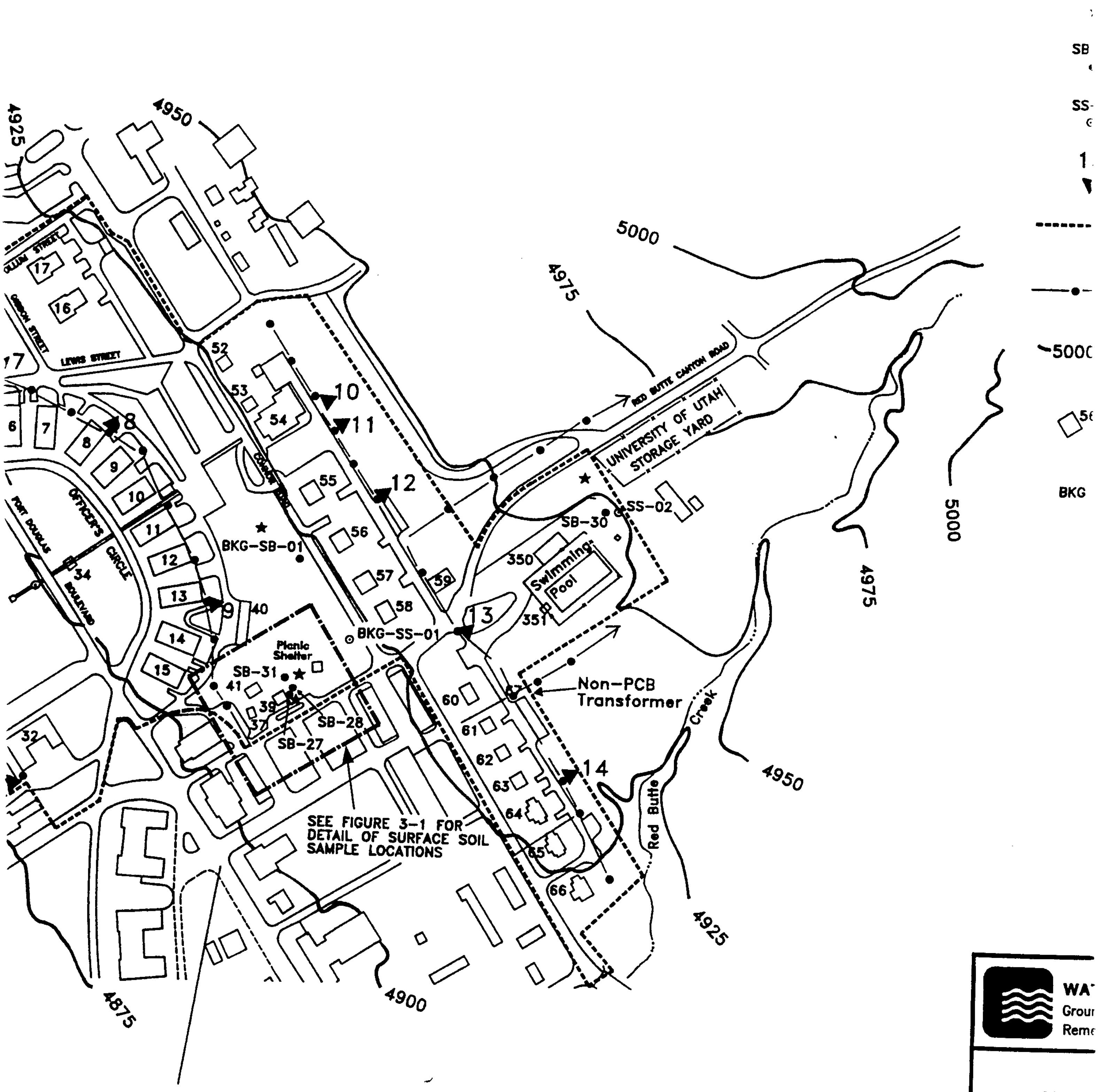
FTD25012\DV2

Date: March 1994 | Figure 3-3

3



Excessed Area
Retained Area
4825
4850
4875
4900
4925
4950
WASATCH DRIVE
PARADE GROUND
SERVICE ROAD
FORT DOUGLAS BOULEVARD
OFFICER'S CIRCLE
LEWIS STREET
GIBBON STREET
FOLLUM STREET
BKG-SB-01
SB-31
SB-27
Picnic Shelter



Retained Area

WA
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NORT

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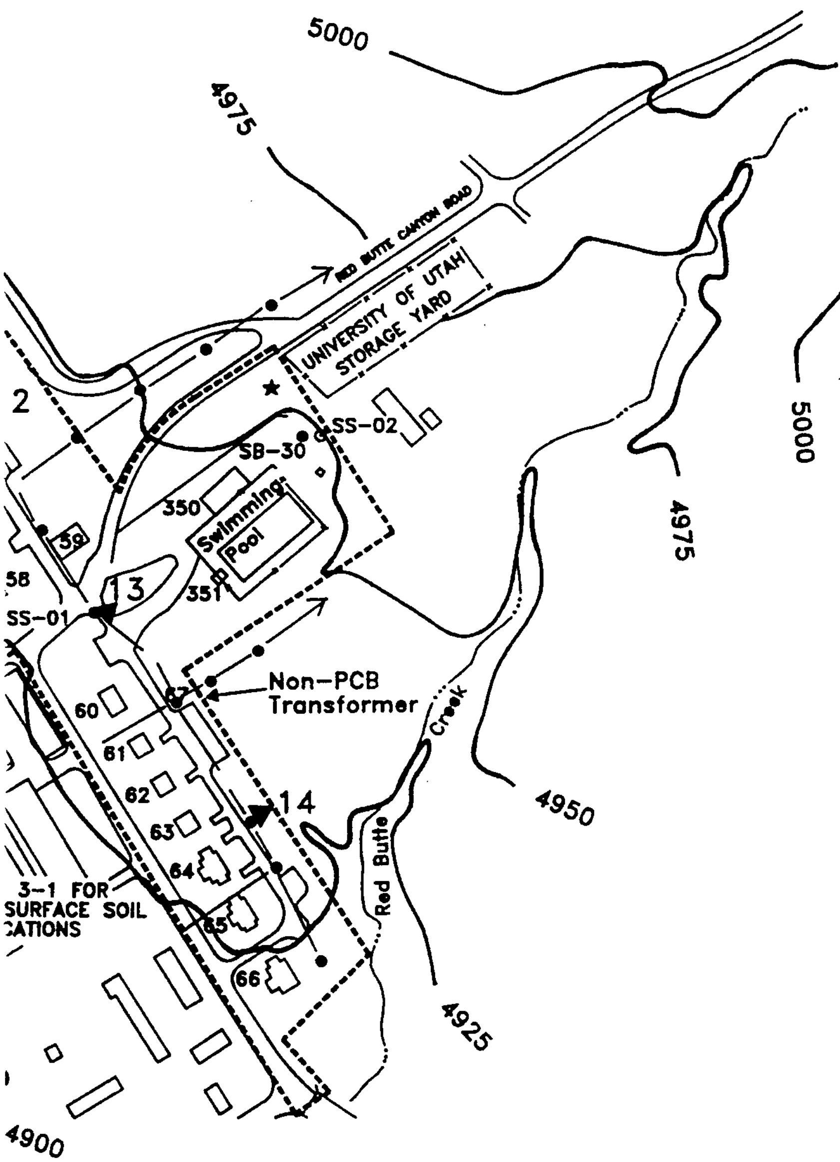
Date: Marc



EXPLANATION

★	Proposed Soil Boring Location
SB-31 ●	Actual Soil Boring Location & Site ID
SS-02 ⊙	Surface Soil Sample Location & Site ID
15 ▼	Transformer Sample Location & Pole Number
-----------	Fort Douglas Excessed Area Boundary
—●—●	Electrical Line with Pole
~5000~	Topographic Contour; Contour Interval 5 ft.
◇56	Sampled Structure with Number
BKG	Background Sample ID

-N-

0 150 300
FEET

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NORTHERN EXCESSED AREA SAMPLE LOCATIONS FORT DOUGLAS

FTD25013\DV1

Date: March 1994 | Figure 3-4

(3)

The boring was located based on the topography of the site. It was drilled as planned, except no surface sample was collected because it was located on an asphalt parking lot. The topography of the area limited moving this boring to a different downslope location that was not on the asphalt. An alternative surface soil sample was collected at a nearby location (SS-02), in order to obtain a sample with the highest possibility of contamination. This sample was analyzed for TPH, metals, and cyanide. The sampling program, modifications to the program, and the rationale for these changes are included on Table 3-2. Soil boring and surface soil sampling locations are shown on Figure 3-4.

3.2.4 BACKGROUND SAMPLES

Background samples were collected to aid in identification of site-specific contamination. During the initial EI field program, one boring was drilled in an area expected to be both contaminant free and representative of Fort Douglas soils. This boring (BKG-SB-01) was located on grass, adjacent to basketball and tennis courts near Conner Road (Figure 3-4). Additional background samples were collected during the supplemental EI field program and included one surface soil sample (BKG-SS-01) from a sodded area (Figure 3-4) and three surface soil samples (BKG-SS-02, BKG-SS-03, and BKG-SS-04) from naturally vegetated areas in the Southeast Fence Line Area (Figure 3-3). These additional samples were analyzed to generate a range of naturally-occurring and anthropogenic (human-made but not site-specific) concentrations of chemicals in the surface soil for different soil types and locations.

The background boring was drilled to a depth of 25.2 ft bgs; auger refusal presented drilling to 30 ft bgs, as originally planned. One surface soil sample and two deeper samples, composited over a 5-ft interval and corresponding stratigraphically to the intervals sampled in the investigative borings, were collected and analyzed for metals and cyanide. Additional, unplanned analyses for VOCs and SVOCs were performed on the deepest sample (19.0 to 21.8 ft bgs) because headspace readings (described in Section 3.2.1) in the field were above background. The location of the background boring was moved approximately 100 ft from the planned location due to water, sewer, and electric lines in the area. The planned and actual locations of Boring BKG-SB-01 are shown on Figure 3-4. The modifications to the soil boring sampling program and rationale for the changes are summarized on Table 3-2.

The surface soil samples collected during the supplemental EI field program were analyzed for SVOCs, TPH, and metals. All samples were collected from 0.0 to 0.5 ft bgs with the exception of BKG-SS-01, which was collected from the 0.0 to 0.5 ft interval below the sod. In the Southeast Fence Line Area near

Hilltop Drive, collection of a sample that was representative of background chemical concentrations was unexpectedly difficult due to the extent of coal and other foreign materials in the soil. The locations of surface soil samples collected in the Southeast Fence Line Area are shown on Figure 3-3. The location of surface soil sample BKG-SS-01 is shown on Figure 3-4.

3.2.5 GEOLOGY AND HYDROGEOLOGY

The soil investigation program generally confirmed previous interpretations of geologic and hydrogeologic information. The area of Fort Douglas that was investigated by soil borings is covered primarily by unconsolidated deposits interpreted to be of alluvial fan origin. Interfingering deposits of lacustrine origin also were penetrated by soil borings. The units were not continuous between borings. Only unconsolidated material was encountered. Disturbed soils, as described in the following paragraph, were penetrated in several of the borings.

The USTs near Building 39 recently had been removed before the initial EI field work. Sod in the area of boring SB-29 was missing, and fill material was present from the ground surface to an approximate depth of 9.6 feet. In the wash rack/oil change/degreasing area near Building 39, pieces of concrete with slight black stain were recovered from boring SB-31. In the Southeast Fence Line Area, fill material consisting of gravel, sand, silt, and clay was present at the surface of boring SB-24. Man-made or used materials, including pieces of brick, ceramic, coal, cast-iron pipe, and masonry were present in subsurface samples from borings SB-26 and SB-27. During the supplemental EI field program, it was noted that much of the surface soil in the Southeast Fence Line Area had been disturbed, as evidenced by the extent of these types of man-made or used materials, particularly coal.

Natural lithologies observed in soil borings primarily included clayey sand with gravel, silty sand, well-sorted sand, and sandy to gravelly clay. Poorly-sorted, reddish-brown units consisting of gravel, sand, and clay components generally are interpreted to be of alluvial fan origin. These deposits are inferred to cover areas of Fort Douglas investigated by EI borings, confirming previous literature. Clay, well-sorted sand, silty sand, and mixtures of sand and clay generally are interpreted to be of shoreline and nearshore lacustrine origin. Although no fossils were observed in EI samples of these lithologic units, shells, likely indicative of a lacustrine environment, were noted in similar lithologies (sandy clay and silty sand) during the ICF investigation. The lacustrine deposits are inferred to interfinger with alluvial fan deposits in the subsurface. This interfingering was observed by Klauk (1986) to also occur at the

University of Utah's Research Park which borders on the east, where the alluvial fan deposits were interpreted to overlie and underlie ancient Lake Bonneville deposits. Some of the sediments penetrated by EI borings may have been deposited in transitional alluvial fan/lacustrine environments and cannot be confidently categorized on the basis of EI data.

Lithologies penetrated by EI borings are described in detail on the Field Log of Boring forms, contained in Appendix E. In general, the field descriptions correlated with the results of the physical soil analyses, also included in Appendix E. Lithologic descriptions of the surface soil samples collected during the supplemental EI field program also are included in Appendix E.

Moisture was present in all four of the soil borings drilled deeper than 5 ft bgs. The wettest zones occurred in lean clay with sand (24 to 25 ft bgs in SB-29; 13.0 to 15.2 ft bgs in SB-28), clayey sand (14.0 to 15.8 ft bgs in BKG-SB-01), clayey sand and gravel (15.0 to approximately 16.1 ft bgs in SB-30), and clayey sand with gravel (24.0 to 25.5 ft bgs in SB-30). Water had been used to compact the fill dirt (used to fill the former tank pits) in the vicinity of borings SB-29 and SB-28; the moisture in these borings may have been in part derived from UST removal activities in August and September 1991. The percentage of fines, primarily clay, in the saturated intervals was estimated to range from 35 percent in SB-30 to 80 percent in SB-28 and SB-29. The highest amount of moisture was observed in boring SB-30 between 15 and 16.1 ft bgs; however, even after the augers were pulled off the bottom of the boring, no ground water could be measured after 30 hours. Ground water was not produced in any of the other borings. It is inferred that the moisture encountered is hydroscopic water retained by capillary forces, and does not represent a ground-water aquifer.

3.3 TRANSFORMER SAMPLING

Previous sampling and current labeling of the transformers at Fort Douglas indicated that PCBs may be present in the transformer oil. No historical releases of potentially PCB-containing oil have been reported. In order to determine if any remedial measures are necessary, all but one of the transformers on the excessed area were targeted for sampling. Manufacturing information for the transformer not sampled was current and stated that this type of transformer does not contain PCBs (Appendix B). This transformer is located southwest of the swimming pool (Figure 3-4).

The sampling team consisted of a licensed journeyman electrician from Wasatch Electric and an environmental scientist from WJE. Prior to sampling at each pole location, the current to the pole was turned off. Occupants of the buildings had been notified previously by the Fort Douglas Directorate of Engineering and Housing (DEH) office of the potential interruption in power. The electrician sampled the transformers from a bucket truck, utilizing a bulb and an unused glass pipette. Two bottles for each transformer were filled, in case of accidental breakage. The length of the pipette was sufficient to sample from the bottom of the transformer, where the PCBs, if present, were expected to be concentrated. Care was taken to avoid spillage. The electrician transferred the sealed sample bottles to the RLSA scientist on the ground, who completed the required documentation.

Either one or three transformers were located on each pole. The pole numbers are shown on Figure 3-4. The transformers are identified by the pole number, followed by a number designating a specific transformer on the pole. The transformers were in good condition with three exceptions, 15-02, 15-03, and 09-01. Transformer 15-02 was observed to be in poor condition. The transformer fluid level was approximately 4 inches lower than observed inside other transformers, approximately 4 inches below the bushings. Heavy oil stains were noted around all bushings on this transformer and about 4 inches below the bushings. No stains were observed on the lower end of the transformer (approximately 1 ft), indicating the oil had not reached the ground. The fluid level in transformer 15-03 was approximately 1 in. below the standard level, and there was a minor residue around the bushings. No stained soil was observed below these transformers. Minor leakage from transformer 09-01 was observed around the bushings and about 4 inches down the transformer. No leakage was observed to reach the ground. All other transformers were observed to be in good condition. Five of the transformers, 04-01, 06-01, 06-02, 06-03, and 08-01, were labeled as PCB-containing. Four of the transformers were labeled as containing less than 50 ppm PCBs (02-01, 03-01, 03-02, 03-03). The three transformers on pole 3 were identified as a non-PCB hazard by the manufacturer's 1982 Code. Three transformers were labeled as containing less than 1 ppm PCBs (13-01, 13-02, 13-03). According to 40 CFR 761.3 (subpart A), a "PCB Transformer" means any transformer that contains 500 ppm PCB or greater, a transformer containing 50 ppm or greater PCB, but less than 500 ppm PCB is classified as "PCB-Contaminated Electrical Equipment", and, by exclusion, a transformer containing less than 50 ppm PCB is a "non-PCB transformer".

A total of 25 transformers at 15 pole locations was scheduled to be sampled. One of the transformers was not present at the time of sampling (05-01). This transformer likely was removed and taken to an

off-post location due to its underutilization (personal communication, Cal Keener, Fort Douglas DEH). A total of 24 transformers was sampled. The samples were analyzed for PCBs on the CERCLA TCL (Table 3-1). Three duplicate samples were collected. The analytical method is described in Appendix D.

The SAP (RLSA, 1991b) stated that if stained soil was observed in the immediate area of the transformers, a surface soil sample would be collected from each location and analyzed for PCBs. No stained soil was observed; therefore, soil samples were not collected and analyzed for PCBs.

3.4 PAINT SAMPLING

Lead-based paints were suspected to be present in almost all of the buildings at Fort Douglas, due to the age of the buildings. No previous sampling for lead-based paint has been conducted. In several structures at Fort Douglas, the paint is in a state of disrepair, potentially releasing lead dust. Paint chips and wipe samples were to be collected and analyzed for lead to provide information regarding potential lead content.

Paint chip samples were collected in areas where the paint was peeling. An approximately 2-in. square sample of all paint layers was collected into a plastic bag using a putty knife. Collection of plaster, wood, and paper was avoided. Wipe samples were collected from areas where potential lead dust may have settled, including window sills, baseboards, door trim, steps, walls, shelves, and radiator covers. Whatman 541 (12.5 centimeter) filter papers, cut in half, were moistened with distilled water, and used to wipe an area of approximately 100 square centimeters (cm^2). The filter paper was folded in half so that the exposed halves of the filter were in contact, then folded once again at a right angle to the first fold, and placed in a plastic bag which was then sealed and labeled. Sample locations were marked on a floor plan, and a Paint/Wipe Sample Log and Assessment Form was filled out for each building. The completed forms summarize the condition of each sampled structure and are included in Appendix F. In general, the paint was in good condition. Family housing units were painted often by Fort Douglas, typically every three years.

An interior paint chip or wipe sample was to be collected from each structure, excluding garages, on the excessed area of Fort Douglas. Multiple samples from structures containing two or more housing units were not planned. A total of 49 structures was scheduled to be sampled; two additional samples were to be collected from exterior paint. Sample collection was conducted as planned. A total of 31 wipe and

18 paint chip samples were collected from the structure interiors (Table 3-3). Two exterior paint chip samples were collected. QC samples consisted of two wipe rinse blanks, one duplicate wipe sample, and one duplicate paint chip sample. All paint chip and wipe samples were analyzed for lead. Analytical methods are described in Appendix D.

3.5 RADON SAMPLING

As part of the Army Radon Reduction Program, radon levels at numerous installations are being investigated. Many areas of Utah are susceptible to elevated radon levels, and as part of a state-wide survey (Sprinkle et al., 1990), a maximum concentration of 26.2 pCi/L was measured in Salt Lake County. Fort Carson conducted the sampling for radon at Fort Douglas.

In order to activate the radon monitors, a protective covering was removed, and the date of placement was recorded on the monitor and on a detector deployment data sheet. Building, room, and floor numbers, building and room use, monitor type, and monitor serial number were also recorded. When removed, each monitor was sealed and labeled with the date, and the detector deployment data sheet was completed.

Between May 1989 and May 1990, a total of 105 long-term (one-year) alpha track monitors (ATMs) and 7 short-term (4 day) charcoal detectors were deployed in 46 excessed structures (Table 3-4). Radon monitors were also placed in retained buildings on the installation. A maximum of 6 monitors were placed in any one structure. Six monitors, including a pair of duplicate samples, could not be retrieved because they were missing.

QC samples included 6 field blanks, 8 spikes, and 14 pairs of duplicate samples. The QA/QC samples were not identified to the laboratory. Monitors used as field blanks were opened when the detectors were collected and were immediately sealed. The monitors sent for spiking were planned to be analyzed with the other field samples; however, the monitors could not be located. QC was provided by spikes sent in at the same time with Fort Carson samples. Duplicate samples were concurrently exposed to the same conditions for the same duration. All samples were shipped to Terradex to be analyzed by Tech/Ops Landauer, Inc.

Table 3-3 Lead-Based Paint Sampling Summary

Structure Number	Housing Unit Sampled	Function	Number of Housing Units	Type of Sample: Interior	Exterior	QC
1	1B	NCO Quarters	2	CHIP	-	-
2	2B	NCO Quarters	2	WIPE	-	-
3	-	Officers Quarters	1	WIPE	-	-
4	-	Administrative Offices	-	WIPE	-	-
5	-	Administrative Offices	-	CHIP	-	-
6	6B	Officers Quarters	2	WIPE	-	-
7	7B	Officers Quarters	2	WIPE	-	-
8	8A	Officers Quarters	2	WIPE	-	DUPL
9	9A	Officers Quarters	2	WIPE	-	-
10	10B	Officers Quarters	2	CHIP	CHIP	DUPL INT
11	11A	Officers Quarters	2	WIPE	-	RINSE
12	12A	Officers Quarters	2	WIPE	-	-
13	13A	Officers Quarters	2	WIPE	-	-
14	14B	Officers Quarters	2	WIPE	-	-
15	15A	Officers Quarters	2	WIPE	-	-
16	16A	NCO Quarters	2	WIPE	-	-
17	17B	NCO Quarters	2	WIPE	-	-
18	18C	Officers Quarters	3	WIPE	-	-
19	19B	Officers Quarters	3	CHIP	-	-
20	-	CO Quarters	1	CHIP	-	-
21	-	Officers Quarters	1	WIPE	-	-
22	-	Officers Quarters	1	WIPE	-	-
23	-	Officers Quarters	1	CHIP	-	-
24	-	Officers Quarters	1	WIPE	-	-
25	-	Officers Quarters	1	WIPE	-	-
31	-	Administrative Offices	-	WIPE	-	-
32	-	Museum	-	CHIP	-	-
37	-	Offices	-	CHIP	-	-
39	-	Latrine	-	CHIP	-	-
41	-	Vacant (former Gas Valve Building)	-	CHIP	-	-
48	-	Post Chapel	-	CHIP	-	-
49	-	Officers Mess	-	WIPE	-	RINSE
52	-	NCO Quarters	1	WIPE	-	-
53	-	NCO Quarters	1	WIPE	-	-
54	-	Community/Family Center	-	CHIP	-	-
55	-	Administrative Offices	-	CHIP	-	-
56	56A	NCO Quarters	2	WIPE	CHIP	-
57	57B	NCO Quarters	2	WIPE	-	-
58	58A	NCO Quarters	2	CHIP	-	-
59	-	NCO Quarters	1	WIPE	-	-
60	60A	NCO Quarters	2	WIPE	-	-
61	-	NCO Quarters	1	CHIP	-	-
62	-	NCO Quarters	1	WIPE	-	-
63	-	NCO Quarters	1	WIPE	-	-
64	64A	NCO Quarters	2	CHIP	-	-
65	65B	NCO Quarters	2	WIPE	-	-
66	66B	NCO Quarters	2	CHIP	-	-
350	-	Bath House	-	CHIP	-	-
351	-	Water Treatment Building	-	WIPE	-	-
TOTALS	--	-		18 CHIPS 31 WIPES	2 CHIPS	2 RINSE 1 DUPL WIPE 1 DUPL CHIP

Table 3-4 Radon Sampling Summary (Page 1 of 2)

STRUCTURE NUMBER	FUNCTION	NUMBER OF HOUSING UNITS	LONG-TERM PROGRAM		SHORT-TERM PROGRAM	
			UNIT(S) SAMPLED	NUMBER OF SAMPLES	UNIT(S) SAMPLED	NUMBER OF SAMPLES
1	NCO Quarters	2	A, B	3*	B	1
2	NCO Quarters	2	A, B	2	B	1
3	Officers Quarters	1	A	1	-	-
4	Administrative Offices	-	-	2	-	-
5	Administrative Offices	-	-	(1) 4*	-	-
6	Officers Quarters	2	A, B	2	-	-
7	Officers Quarters	2	A, B	3*	-	-
8	Officers Quarters	2	A, B	2	-	-
9	Officers Quarters	2	A, B	3*	-	-
10	Officers Quarters	2	A, B	3*	-	-
11	Officers Quarters	2	A, B	2	-	-
12	Officers Quarters	2	A, B	2	-	-
13	Officers Quarters	2	A, B	3*	-	-
14	Officers Quarters	2	A, B	2	-	-
15	Officers Quarters	2	A, B	2	-	-
16	NCO Quarters	2	A, B	2	-	-
17	NCO Quarters	2	A, (B)	(1) 1	-	-
18	Officers Quarters	3	A, B, C	3	C	1
19	Officers Quarters	3	A, B, C	4*	C	1
20	CO Quarters	1	-	3	-	-
21	Officers Quarters	1	-	1	-	-
22	Officers Quarters	1	-	1	-	-
23	Officers Quarters	1	-	1	-	-

* The number includes a duplicate sample.
Parentheses indicate monitors that could not be retrieved from structure.

Note: Six field blanks and eight spikes were submitted with the samples.

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Table 3-4 Radon Sampling Summary (Page 2 of 2)

STRUCTURE NUMBER	FUNCTION	NUMBER OF HOUSING UNITS	LONG-TERM PROGRAM		SHORT-TERM PROGRAM	
			UNIT(S) SAMPLED	NUMBER OF SAMPLES	UNIT(S) SAMPLED	NUMBER OF SAMPLES
24	Officers Quarters	1	-	1	-	-
25	Officers Quarters	1	-	1	-	-
31	Administrative Offices	-	-	3	-	-
32	Museum	-	-	6*	-	-
39	Latrine	-	-	(1)	-	-
48	Post Chapel	-	-	4	-	-
49	Officers' Mess	-	-	(2*), 2	-	2
52	NCO Quarters	1	-	2*	-	-
54	Community/Family Center	-	-	4	-	-
55	Administrative Offices	-	-	2*	-	-
56	NCO Quarters	2	(A), B	(1), 1	-	-
57	NCO Quarters	2	A, B	3*	-	-
58	NCO Quarters	2	A, B	2	-	-
59	NCO Quarters	1	-	1	-	-
60	NCO Quarters	2	A, B	2	-	-
61	NCO Quarters	1	-	1	-	-
62	NCO Quarters	1	-	1	-	-
63	NCO Quarters	1	-	2*	-	-
64	NCO Quarters	2	A, B	2	-	-
65	NCO Quarters	2	A, B	2	B	1
66	NCO Quarters	2	A, B	3*	-	-
350	Bath House	-	-	1	-	-
351	Water Treatment Bldg.	-	-	1	-	-

* The number includes a duplicate sample.
Parentheses indicate monitors that could not be retrieved from structure.

Note: Six field blanks and eight spikes were submitted with the samples.

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3.6 WASTE MANAGEMENT

Potentially hazardous wastes generated by the field investigation included soil cuttings, decontamination water, transformer sampling equipment, and protective clothing. These wastes have been handled in accordance with the requirements of RCRA and in accordance with Title 40 of the Code of Federal Regulations (CFR), Part 261.

Drill cuttings were screened in the field for the presence of organic vapors using the headspace technique described in Section 3.2.1. The headspace analysis indicated that the concentration of organic vapors was less than 5 ppm in all samples except for two collected from soil boring BKG-SB-01. Therefore, with the exception of soil from BKG-SB-01, all soil was disposed at the boring site as nonhazardous, in accordance with the SAP (RLSA, 1991b; Section 3.4). Soil from boring BKG-SB-01 was containerized in a drum that was labeled with the boring number, contents, and date of accumulation.

Wastewater and plastic sheeting from decontamination and transformer sampling equipment, including pipettes, wipers, bulbs, and protective clothing also were containerized in labeled drums.

Analytical results from the EI for soil boring samples indicated that the soil, decontamination water, and plastic sheeting were not RCRA hazardous waste material. Analysis of transformer oil samples showed PCBs were present in two samples. The waste has been disposed of at the United States Pollution Control Inc. (USPCI) Grassy Mountain Facility in Toole County, Utah, in accordance with all applicable rules and regulations of the State of Utah and the USEPA.

3.7 TOPOGRAPHIC AND LOCATION SURVEY

Boring and surface soil locations were measured utilizing a tape measure and previously surveyed features, such as buildings and fences. These locations were plotted on a topographic map (General Storm Drainage Map, March 1983) and an aerial photo map (Aerial Photo-Contour Map, August 1968) of Fort Douglas, and the elevations and coordinates were interpolated. Locations of the transformers were identified on the previously existing Fort Douglas General Electric Map (March 1983), and the coordinates were interpolated. Paint chip and wipe sample locations were identified by the coordinates of the center of the buildings from which they were collected.

3.8 DATA REPORTING

Analytical reports were submitted immediately after the completion of the analyses and the associated calculations. A typical analytical report is comprised of the analytical results and limits of detection.

A copy of all reports was placed in a master file for storage and retrieval of information as required. This file is organized and maintained according to laboratory sample number and general sample type. Material filed for each sample set includes reports of analytical results, methodology, and QC results.

All reported data fulfilled USAEC requirements. All numerical results are reported in terms of concentration in the environmental sample. Concentrations submitted for entry into Installation Restoration Data Management Information System (IRDMIS) remain unadjusted before being reported to USAEC. Correction factors (e.g., accuracy, percent moisture, and dilution factor) are maintained separately in the IRDMIS. All data were collected during periods when calibration and control systems were used. Only concentrations measured within the certified range, prior to correction, were reported. Specific instructions are provided in the IRDMIS User's Guide regarding the coding of entries. Flagging codes, as described in Section 3.2.2 and the IRDMIS User's Guide, were used when applicable to comment on the usability of the data. Comments on the usability of the data are provided.

The method blank results are subtracted from quality control samples only, and the actual method blank values are reported to IRDMIS. Each analytical method describes the correct procedure for using method blank results. In reporting results, rounding to the correct number of significant figures occurs only after all calculations and manipulations are completed. Premature rounding can significantly affect the final result.

In rounding numbers, the following rules were used:

- increase the last retained digit by one if the residue is larger than 5;
- retain the last digit unchanged if the residue is less than 5; and
- retain the last digit unchanged if even, or increase it by one if odd, if the residue is exactly 5.

The residue is defined as the single digit number (an uncertain value) following the significant figures (the numbers that are of definite value).

For Gas Chromatogrpahy/Mass Spectrometry (GC/MS) methods (Class 1A), results for certified target analytes are reported to two significant figures if the method was used without dilution. Results obtained after dilution and results of screening for non-certified analytes are reported to only one significant figure.

Results for analytes detected by non-GC/MS methods (Class 1 and Class 1B) are reported to three significant figures. If dilution was required for a particular analyte, the result was reported to two significant figures, reflecting the fact that total method performance was not demonstrated at that concentration during certification.

Several non-certified methods were used for the Fort Douglas EI samples, including TPH, lead content in paint chips and wipes, and PCB concentrations in transformer oil. These results are reported to one significant figure. Radon results are reported as they were received from Fort Carson.

The rounding and significant figure guidelines discussed above were used in reporting results in the detection summary tables in Section 4.0. Results in the IRDMIS may include additional figures.

3.9 DATA MANAGEMENT

Data generated from sample collection have been managed in accordance with USAEC data management procedures for collecting, storing, controlling, reporting, and transferring project data. Data for this project include chemical data from the laboratory, ESE, and geotechnical data from the field drilling program. The objective of the data management effort is to ensure the field data and analytical results are organized, coded, and entered into the USAEC IRDMIS. Additionally, data entered into the IRDMIS were checked for errors using IRDMIS programs. All data that passed the error check were sent to USAEC for additional qualification. A final objective is the reporting of qualified data to authorized users.

The chemical analysis data for Fort Douglas were transferred to WJE from the laboratory, reviewed for completeness and consistency, run through a group and record check using IRDMIS programs, and uploaded to the IRDMIS. Boring log information also was uploaded to the IRDMIS. The IRDMIS

software is an application written for the IBM PC/XT or PC/AT. This software provides for the entry, error checking, and output of chemical and field data. There are three levels of data recognized in the IRDMIS. Level 1 (unofficial data) consists of all data entered on the PC from field logs and from electronic data provided by the analytical lab. Once data has been entered at level 1, the data are checked using programmed verification modules. Data were edited and rechecked before being sent to USAEC.

Level 1 data transferred to USAEC were checked manually for errors. If errors were detected, the WJE data manager was notified, required corrections were made, and the data were resubmitted to USAEC. Data that passed final error checks were classified as Level 2 data. Level 2 data were then qualified by USAEC Chemistry Branch. The Chemistry Branch qualifies all data and has the authority to code data as to its usability, for lots and individual parameters if their review of laboratory QA/QC indicates conditions out of control. The final qualified Level 2 data were then processed to Level 3. Level 3 data are stored on USAEC's mainframe computer. The Level 3 data may be accessed for reporting and downloaded for reporting data management.

All original logbooks, field data sheets, photographs, and hardcopy of chemical/geotechnical data will be supplied to USAEC. Original, uncorrected copies of the field boring logs were submitted to USAEC upon completion of the initial EI field program.

4.0 NATURE AND EXTENT OF CONTAMINATION

Analytical results for the samples collected, including soil, transformer oil, paint wipes, paint chips, and radon are discussed in the following sections. The results are included as Appendix G. The soil results are presented for the background soil, and soil in or near potential contaminant source areas. A discussion of the QA/QC program results for all media is included in this section in order to aid in evaluation of the sampling and analysis methods as related to the investigative sample results.

4.1 QUALITY ASSURANCE/QUALITY CONTROL RESULTS

In accordance with the QA/QC program, source water, rinse blank, trip blank, and duplicate samples were collected during the EI field program and submitted to the laboratory. Two samples were collected from the approved water source to determine if any site-related contaminants were present in the water planned to be used for decontamination. The number of other field QC samples collected was based on a percentage of total samples collected. The field QC blank samples included two wipe rinse blanks, four soil rinse blanks, and three trip blanks. Six blanks were submitted as part of the Army radon program. Duplicate QC samples included three transformer oil samples, 14 radon samples, three soil samples, one wipe sample, and one paint chip sample. These field QC samples were used to evaluate the potential for sample cross-contamination during shipping, the effectiveness of decontamination and sampling procedures, and analytical precision.

As part of the system control for the QA/QC program, method blanks were prepared at the laboratory and analyzed with each sample lot. Method blank results were examined by WJE after all analytical data were received to determine if the laboratory was a source of sample contamination to specific sample lots.

4.1.1 SUMMARY OF SOURCE WATER DETECTIONS

The water used for decontamination of drilling and soil sampling equipment was obtained from a fire hydrant located on Pollock Road near Building 234. The water was from one of Salt Lake City Water Utilities treatment plants. No untreated water was available on Fort Douglas. Two samples of the water were collected in June 1991 and analyzed for VOCs, SVOCs, PCBs, TPH, metals, and cyanide to determine if any site-related contaminants were present in the water. Chloroform was detected at 38 and 40 μg/L, and bromodichloromethane was detected at 2.2 and 3.2 μg/L (Table 4-1). No other organics

Table 4-1 Summary of Source Water Detections

Site ID Sample Date	SORQ1 06/25/91	SORQ1D 06/25/91
ORGANICS		
Bromodichloromethane	3.2	2.2
Chlorofom	40	38
INORGANICS		
Aluminum	976	1,070
Arsenic	<2.3	2.8
Barium	31.8	34.3
Cadmium	3.07	2.75
Calcium	21,900	24,000
Copper	20.3	24.7
Iron	2,510	2,700
Lead	4.8	2.2
Magnesium	5,890	6,350
Manganese	58.7	65.4
Nickel	7.36	10.2
Potassium	945	1,130
Sodium	4,730	5,030
Zinc	30.4	38.2

Units are in $\mu g/L$
$\mu g/L$ = parts per billion
< = less than certified reporting limit
D = duplicate

were detected. Several inorganics were detected; the concentrations are within the range of typical treated water standards and are included on Table 4-1.

This source of water also was used during the ICF UST investigation. Previous analyses also indicated the presence of chloroform and bromodichloromethane at similar concentrations. These compounds typically form as a result of the reactions of chlorine (applied during prechlorination/postchlorination) with decaying organic matter typically present in untreated water. Chloroform and bromodichloromethane were not expected to be related to site-specific contamination; therefore, the source was approved by USAEC.

4.1.2 EVALUATION OF FIELD-GENERATED QC BLANK DATA

Method Blank Data - Method blank data for sample lots with detections of organics unrelated to site contaminants and typically used in laboratory procedures were examined to evaluate potential laboratory contamination. Methylene chloride, diethyl phthalate, di-N-butyl phthalate, and bis(2-ethylhexyl) phthalate were reported in the method blanks, indicating that these compounds were introduced at the laboratory. Because these are common laboratory contaminants, each detection in the investigative samples that is associated with a method blank detection in the same lot is qualified by elevating the limit of detection when the sample concentration is less than 10 times the blank concentration (USEPA, 1988a). In all lots where these contaminants were detected in EI samples, the investigative sample concentration was less than 10 times the method blank concentration; therefore, these detections can be qualified as non-detects (USEPA, 1988a). These concentrations are identified on the detection summary tables in the following sections.

Field-Generated Blank Data - Results of the two types of field blanks collected, trip and rinse, can be used to identify, and where possible, to estimate the magnitude of contamination introduced during the sampling, shipping, and analysis processes. Contamination detected in the field QC blanks was not used to correct or qualify investigative data, but was evaluated to determine whether the analytes detected in the investigative samples generally represented field concentrations.

Detections in the field blanks are summarized in Table 4-2. Organics, including bis(2-ethylhexyl) phthalate (1.8 μg/L), chloroform (5.2 μg/L), and TPH (100,000 μg/L) were detected in one of the rinse blanks from the soil sampling equipment (polybutyrate liners). Bis(2-ethylhexyl) phthalate (1.5 μg/L)

Table 4-2 Field QC Blank Detections Summary

MEDIA	SITE ID	ANALYTE	BLANK ARTIFACT CONCENTRATION	INVESTIGATIVE SAMPLE CONCENTRATION
RINSE BLANKS				
SOIL	SB-29	**Organics**		
		Total Petroleum Hydrocarbons	300 µg/L	60 µg/g
		Inorganics		
		Beryllium	2.09 µg/L	<50 µg/g
		Calcium	224 µg/L	37,000 µg/g
		Copper	13.5 µg/L	<94 µg/g
	SB-31	**Organics**		
		Bis(2-ethylhexyl) phthalate	1.8 µg/L*	<0.39 µg/g
		Chloroform	5.2 µg/L	<0.002 µg/g
		Total Petroleum Hydrocarbons	100,000 µg/L	500 µg/g
		Inorganics		
		Calcium	191 µg/L	66,000 µg/g
		Copper	12.7 µg/L	<190 µg/g
	SS-05	**Organics**		
		Bis(2-ethylhexyl) phthalate	1.5 µg/L	<0.39 µg/g
		Inorganics		
		Calcium	126 µg/L	92,000 µg/g
		Copper	29.2 µg/L	23.3 µg/g
		Zinc	38.9 µg/L	70.0 µg/g
	SS-10	**Inorganics**		
		Calcium	121 µg/L	48,000 µg/g
		Lead	1.52 µg/L	52 µg/g
PAINT WIPE	11A-001	Lead	0.03 µg/cm²	0.1 µg/cm²
	49-001	No lead detected		
TRIP BLANKS				
SOIL	SB-28	No volatile organics detected		
	SB-29	No volatile organics detected		
	SB-31	No volatile organics detected		
AIR	1377780	Radon	0.2 pCi/L	NA
	1377851	Radon	0.2 pCi/L	NA
	1385985	Radon	0.3 pCi/L	NA
	1385992	Radon	0.2 pCi/L	NA
	1413623	Radon	0.2 pCi/L	NA
	1413636	Radon	0.2 pCi/L	NA

< = less than certified reporting limit
µg/cm² = micrograms per square centimeter
µg/L = parts per billion
µg/g = parts per million
pCi/L = picocuries per liter of air
NA = not applicable
* = also detected in the method blank for this lot and can be qualified as ubiquitous or a lab contaminant (Section 4.1.2)

and TPH (300 μg/L) also were detected in rinse blanks for SS-05 and SB-29, respectively. Inorganics detected in the soil rinse blanks included beryllium, calcium, copper, lead, and zinc. Lead was detected in one of the two wipe rinse blanks at a concentration of 0.03 $\mu g/cm^2$. No volatile organics were detected in the trip blanks. Radon was detected in all six trip blanks, from 0.2 to 0.3 pCi/L.

Bis(2-ethylhexyl) phthalate was reported in the method blank for the lot that included the soil rinse blank associated with samples from boring SB-31; and therefore is considered a laboratory contaminant. Although bis(2-ethylhexyl) phthalate was not detected in the method blank for the lot containing the rinse blank for SS-05, this additional occurrence in a rinse blank also may be due to laboratory contamination or to the ubiquitous nature of phthaltes. In addition, because chloroform was not detected in the associated investigative soil sample or in any other EI samples, this detection may indicate the introduction of contamination into the sample at the laboratory. Concentrations of TPH in two of the soil rinse blanks imply potential laboratory or method problems, and not decontamination or source (distilled) water factors, because the polybutyrate liners were not used for previous sample collection, and TPH concentrations differed between the blanks, which were collected from distilled water poured over steam-cleaned polybutyrate liners. Both TPH and chloroform should be considered potential artifacts.

The inorganic concentrations reported in the soil rinse blanks were similar in the samples and/or are within the range of concentrations found in natural or drinking water. Therefore, the inorganic data appear to be representative of actual concentrations. However, the rinse blank results have limited applicability, because they were produced from water methods, and not soil methods, as were the investigative sample results.

The absence of lead in one of the wipe blank samples, the low concentration of lead in the other wipe blank sample, and the consistent low concentrations of radon in all blank ATM samples indicate that these types of data generally have not been significantly altered by field or laboratory practices. In addition, the trip blank results indicated that volatiles were not absorbed by the soil samples and no cross-contamination occurred.

4.1.3 Evaluation of Duplicate Data

Field duplicate results are a measure of the precision of both sampling and analysis, and therefore, may have more variability than laboratory duplicates which measure only laboratory performance. Duplicate

samples were analyzed for three transformer oil samples, one paint wipe sample, one paint chip sample, and 13 radon samples. In addition, three soil samples were split at the laboratory and analyzed as six separate samples. The paired analytical results were assessed by calculating the percent relative difference (%RD) for each data pair. The calculation is as follows:

$$\%RD = \frac{|S-D|}{(S+D)/2} \times 100$$

S = First Sample Value (original)

D = Second Sample Value (duplicate)

Calculations were performed for those duplicate analyses where at least one positive identification and quantitation was reported. In general, the % RD values are meant to provide a general indication of reproducibility and should not be evaluated quantitatively. There are no review criteria for field duplicate analyses comparability. The guidelines for laboratory duplicates are a control limit of ± 20 % RD for sample values greater than five times the CRL.

Table 4-3 shows the analytes that were detected in at least one of the duplicate samples, concentrations in both samples, and the % RD for each analyte, by media. Because of the limited number of each type of duplicate samples, with the exception of radon samples, an assessment of reproducibility or reliability for each media, analyte, or method would not be meaningful. The % RD for TPH in one of the duplicate soil samples (200) was the highest for all media and all analytes. The high % RD is due to the imprecision inherent in the analytical method and is not a concern. A % RD of 100 was calculated for phenanthrene in one of the duplicate soil samples. This % RD is high because phenanthrene was not detected in one of the samples, which was diluted by five times, and it was detected slightly above the CRL in the other sample. All other % RDs for soil analytes did not exceed 59 percent. Percent RD values for paint wipe and paint chip samples were 20 percent and 0 percent, respectively. The duplicate radon results ranged from 0.0 to 36 % RD, with an average value of 6.9 % RD. The results indicate radon sampling and analysis methods can be considered reliable.

Table 4-3 Summary of Duplicate Sample Analyses (Page 1 of 2)

MEDIA	SITE ID	ANALYTE	CONCENTRATION	DUPLICATE CONCENTRATION	% RD
TRANSFORMER OIL	02-01	No PCBs detected	-	-	-
	10-01	No PCBs detected	-	-	-
	14-01	No PCBs detected	-	-	-
PAINT WIPE (units in $\mu g/cm^2$)	8A-001	Lead	0.07	0.06	20
PAINT CHIP (units in $\mu g/g$)	10B-001	Lead	400,000	400,000	0
SOIL (units in $\mu g/g$)	SB-29	**Organics**			
		Acetone	0.051	<0.046	10
		Di-N-butyl phthalate	2.4*	4.4	NC
		Total Petroleum Hydrocarbons	100	<10	200
		Inorganics			
		Aluminum	16,000	15,000	6.5
		Arsenic	7.02	8.02	13.3
		Calcium	85,000	80,000	6.1
		Iron	21,000	21,000	0.0
		Lead	20	13	42
		Magnesium	15,000	16,000	6.5
		Manganese	570	<400	35
	SS-04	**Inorganics**			
		Aluminum	17,000	13,000	27
		Arsenic	3.90	4.13	5.73
		Barium	139	152	8.93
		Beryllium	1.43	1.12	24.3
		Cadmium	1.49	1.30	13.6
		Calcium	59,000	71,000	18
		Chromium	35.7	31.2	13.4
		Cobalt	20.9	18.1	14.4
		Copper	30.8	33.1	7.20
		Lead	21,000	15,000	33
		Iron	53	54	1.9
		Magnesium	9,600	8,300	14
		Manganese	665	667	0.300
		Mercury	0.044	0.040	9.5
		Nickel	23.2	21.7	6.68
		Potassium	4,620	3,250	34.8
		Silver	0.843	0.835	0.954
		Sodium	200	183	8.88
		Thallium	79.3	62.5	23.7
		Vanadium	29.1	23.0	23.4
		Zinc	89.7	88.2	1.69

Table 4-3 Summary of Duplicate Sample Analyses (Page 2 of 2)

MEDIA	SITE ID	ANALYTE	CONCENTRATION	DUPLICATE CONCENTRATION	% RD
SOIL (units in $\mu g/g$)	SS-12	**Organics**			
		2-Methylnaphthalene	0.076	0.073	4.03
		Naphthalene	0.061	0.059	3.33
		Phenanthrene	0.041	<0.2	100
		Total Petroleum Hydrocarbons	2,000	2,000	0
		Inorganics			
		Aluminum	13,000	9,400	32
		Arsenic	4.22	5.06	18.1
		Barium	191	175	8.74
		Beryllium	1.08	0.929	15.0
		Cadmium	1.40	1.29	8.18
		Calcium	33,000	>50,000	41
		Chromium	24.4	25.6	4.80
		Cobalt	16.7	13.9	18.3
		Copper	33.9	35.6	4.89
		Iron	16,000	13,000	20.7
		Lead	150	170	12
		Magnesium	6,600	5,900	11
		Manganese	669	594	11.9
		Mercury	0.142	0.152	6.80
		Nickel	17.3	15.3	12.3
		Potassium	3,530	2,910	19.2
		Silver	0.715	1.09	41.6
		Sodium	198	108	58.8
		Thallium	64.4	59.7	7.57
		Vanadium	24.1	17.6	31.2
		Zinc	177	158	11.3
AIR (units in pCi/L)	1A	Radon	2.1	2.0	4.9
	5	Radon	1.3	1.4	7.4
	7A	Radon	1.5	1.7	13
	9B	Radon	2.9	2.9	0.0
	10A	Radon	3.6	3.7	2.7
	13B	Radon	3.8	3.4	11
	19B	Radon	2.9	3.1	6.7
	32	Radon	1.3	0.9	36
	52	Radon	1.6	1.6	0.0
	55	Radon	1.3	1.2	8.0
	57B	Radon	2.7	2.7	0.0
	63	Radon	1.1	1.1	0.0
	66B	Radon	1.4	1.4	0.0

< = less than detection limit or certified reporting limit
> = greater than certified reporting limit
$\mu g/cm^2$ = micrograms per square centimeter
$\mu g/g$ = parts per million
pCi/L = picocuries per liter of air
* = also detected in the method blank for this lot and can be qualified as ubiquitous or a lab contaminant (Section 4.1.2)
NC = not calculated; % RD would not be valid

4.2 BACKGROUND SOILS

The background boring (BKG-SB-01) was drilled in a grassy area near the basketball and tennis courts along Conner Road during the initial EI field program. This area was expected to be both contaminant free and representative of Fort Douglas soils (Figure 3-4). Three samples were submitted to the laboratory for analysis. A surface soil sample, composed primarily of silt, with clay and sand, and a deeper sample of clay, collected from 9.0 to 13.6 ft bgs, were analyzed for metals and cyanide. A sample of gravelly clay with sand collected from 19.0 to 21.8 ft bgs, was analyzed for VOCs, SVOCs, metals, and cyanide. Organic analyses were requested for this sample because headspace measurements for this interval were above background.

During the supplemental EI field program, one surface soil sample was collected from a sodded area in the northern excessed portion of Fort Douglas (BKG-SS-01; Figure 3-4) and three surface soil samples were collected from naturally vegetated areas in the Southeast Fence Line Area (BKG-SS-02, BKG-SS-03, BKG-SS-04; Figure 3-3). Analytical data for these samples were expected to represent background concentrations of metals and organics. In the sodded area, sample BKG-SS-01 was collected from the 0.0 to 0.5 ft interval below the sod. All other samples were collected from 0.0 to 0.5 ft bgs. The samples were analyzed for SVOCs, TPH, and metals. All samples consisted of silt, with varying percentages of sand and gravel.

Diethyl phthalate (0.69 μg/g) and di-N-butyl phthalate (2.0 μg/g) were detected in the 19.0 to 21.8 ft bgs sample from the boring; however, they are interpreted to be a result of laboratory contamination, based on method blank data (Table 4-4). Pyrene was detected in surface soil sample BKG-SS-01 at a concentration of 0.042 μg/g, slightly above the CRL of 0.033 μg/g. TPH concentrations in the surface soil samples ranged from less than 10 μg/g in BKG-SS-03 to 90 μg/g in BKG-SS-04. All inorganics on the TCL were detected with the exception of cyanide (only analyzed in the soil boring samples), antimony, and selenium. Concentration ranges of all detected analytes are shown on Table 4-4.

As indicated by Table 4-4, concentrations of some of the metals in the background soil samples varied widely. For example, the concentration of lead detected in the 0.0 to 0.5 ft bgs sample from BKG-SB-01 (82 μg/g) was 19 times higher (greater than one order of magnitude) than the concentration detected in the 19.0 to 21.8 ft bgs from this boring (4.21 μg/g). Reasons for this variability include differences in geology and ambient conditions for each location, the inherent heterogeneity in soil samples, and

Table 4-4 Summary of Background Soil Detections (Page 1 of 2)

Site ID	BKG-SB-01	BKG-SB-01	BKG-SB-01	BKG-SS-01	BKG-SS-02	BKG-SS-03	BKG-SS-04	Range of Concentrations	Highest Detected Concentration
Sample Interval (ft)	0.0-0.5	9.0-13.6	19.0-21.8	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5		
Sample Date	10/02/91	10/02/91	10/02/91	7/15/92	7/16/92	7/16/92	7/16/92		
Lithology	Silt with sand and clay (topsoil)	Clay	Gravelly clay with sand	Silt (topsoil)	Silt with gravel	Silt with gravel	Silt with sand and gravel		
ORGANICS (units in µg/g)									
Diethyl phthalate	NR	NR	0.69*	<0.19	<0.19	<0.19	<0.19	<0.19-0.69	0.69
Di-N-butyl phthalate	NR	NR	2.0*	<0.92	<0.92	<0.92	<0.92	<0.92-2.0	2.0
Pyrene	NR	NR	<0.033	0.042	<0.033	<0.033	<0.033	<0.033-0.042	0.042
Total Petroleum Hydrocarbons	NR	NR	NR	20	20	<10	90	<10-90	90
INORGANICS (units in µg/g)									
Aluminum	10,000[1]	14,000[2]	10,000[3]	21,000[5]	9,300[6]	8,300[6]	6,900[6]	6,900-21,000	21,000
Arsenic	4.54	7.69	3.18	4.71	4.92	5.10	6.12	3.18-7.69	7.69
Barium	91[1]	<96[2]	<190[3]	146	118	135	109	91-146	146
Beryllium	<25[1]	<50[2]	<100[3]	1.73	0.914	0.927	0.910	0.910-1.73	1.73
Cadmium	<26[1]	<52[2]	<100[3]	1.93	0.848	0.732	0.730	0.730-1.93	1.93
Calcium	14,000[1]	81,000[3]	71,000[3]	25,000[5]	40,000[4]	62,000[7]	94,000[7]	14,000-94,000	94,000
Chromium	<33[1]	<67[2]	<130[3]	48.1	21.9	24.1	28.4	21.9-48.1	48.1
Cobalt	<33[1]	<67[2]	<130[3]	22.3	14.1	13.6	11.3	11.3-22.3	22.3
Copper	<47[1]	<94[2]	<190[3]	39.6	22.8	24.7	32.0	22.8-39.6	39.6
Iron	12,000[1]	15,000[2]	12,000[3]	21,000[5]	11,000[6]	11,000[6]	8,500[6]	8,500-21,000	21,000
Lead	82[4]	11.1	4.21	14[5]	25[4]	14[5]	73[4]	4.21-82	82
Magnesium	5,300[1]	14,000[2]	15,000[3]	7,400[5]	7,400[6]	8,800[6]	6,900[6]	5,300-15,000	15,000

µg/g = parts per million
NR = not requested
< = less than certified reporting limit or detection limit
1 - dilution factor of 50
2 - dilution factor of 100
3 - dilution factor of 200
4 - dilution factor of 10
5 - dilution factor of 5
6 - dilution factor of 2
7 - dilution factor of 20
* - also detected in the method blank for this lot and can be qualified as ubiquitous or a lab contaminant (Section 4.1.2).

Table 4-4 Summary of Background Soil Detections (Page 2 of 2)

Site ID	BKG-SB-01	BKG-SB-01	BKG-SB-01	BKG-SS-01	BKG-SS-02	BKG-SS-03	BKG-SS-04	Range of Concentrations	Highest Detected Concentration
Sample Interval (ft)	0.0-0.5	9.0-13.6	19.0-21.8	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5		
Sample Date	10/02/91	10/02/91	10/02/91	7/15/92	7/16/92	7/16/92	7/16/92		
Lithology	Silt with sand and clay (topsoil)	Clay	Gravelly clay with sand	Silt (topsoil)	Silt with gravel	Silt with gravel	Silt with sand and gravel		
Manganese	470^{1}	390^{2}	900^{3}	702	516	443	408	390-900	900
Mercury	<0.027	<0.027	<0.027	0.052	<0.027	<0.027	<0.027	<0.027-0.052	0.052
Nickel	$<77^{1}$	$<150^{2}$	$<310^{3}$	25.4	17.2	16.8	12.9	12.9-25.4	25.4
Potasssium	$<6{,}000^{1}$	$<12{,}000^{2}$	$<24{,}000^{3}$	5,040	2,440	1,870	1,830	1,830-5,040	5,040
Silver	$<26^{1}$	$<52^{2}$	$<100^{3}$	0.875	<0.521	0.746	1.26	<0.521-1.26	1.26
Sodium	$<2{,}200^{1}$	$<4{,}500^{2}$	$<9{,}000^{3}$	370	147	102	<44.8	<44.8-370	370
Thallium	$<740^{1}$	$<1{,}500^{2}$	$<2{,}900^{3}$	84.9	43.7	42.3	37.7	37.7-84.9	84.9
Vanadium	$<89^{1}$	$<180^{2}$	$<350^{3}$	33.6	18.2	19.5	15.4	15.4-33.6	33.6
Zinc	$<97^{1}$	$<190^{2}$	$<390^{3}$	87.9	55.8	46.8	147	46.8-147	147

μg/g = parts per million
NR = not requested
< = less than certified reporting limit or detection limit
1 - dilution factor of 50
2 - dilution factor of 100
3 - dilution factor of 200
4 - dilution factor of 10
5 - dilution factor of 5
6 - dilution factor of 2
7 - dilution factor of 20
* - also detected in the method blank for this lot and can be qualified as ubiquitous or a lab contaminant (Section 4.1.2).

analytical imprecision. Statistical comparisons of the geometric means and variances for the background data set and the investigative sample data set indicated that only calcium is elevated in the investigated area. Comparison of the 95th percent upper bound confidence limit (95UCL) for the two data sets indicate magnesium, mercury, and zinc are elevated with respect to background area concentrations. However, in the following sections, additional comparison of individual sample concentrations to background concentration ranges is also described to provide more location-specific information.

4.3 BUILDING 39 AREA

Three soil borings were drilled to varying depths in this area during the initial EI field program. Borings SB-28 and SB-31 were drilled to investigate the wash rack/oil change/degreasing area, and boring SB-29 was drilled to investigate the former USTs. All soil samples were analyzed for TPH, metals, and cyanide. Samples collected below 0.5 ft bgs were also analyzed for VOCs and SVOCs. During the supplemental EI field program, six surface soil samples (SS-03 through SS-08) were collected from the 0.0 to 0.5 ft interval below the sod in the vicinity of the wash rack/oil change/degreasing area. These samples were analyzed for SVOCs, TPH, and metals.

TPH detections, ranging up to 500 μg/g in the 0.5 to 3.2 ft bgs sample from boring SB-31, were reported in seven of the samples from the soil borings (Table 4-5). Several semivolatile organics, primarily polycyclic aromatic hydrocarbons (PAHs) and phthalates, were detected in the 0.5 to 5.0 ft bgs sample from boring SB-28 and in the 0.5 to 3.2 ft bgs sample from boring SB-31. In SB-28, PAH concentrations did not exceed 0.35 μg/g (fluoranthene). The PAH reported at the highest concentration in boring SB-31 was fluoranthene, detected at 0.16 μg/g. The phthalate detections in all three borings can be attributed to laboratory contamination on the basis of method blank data or to the ubiquitous nature of phthalates. Acetone, another common laboratory contaminant, was detected in two samples from boring SB-29. Metals concentrations were similar to levels detected in the background soil samples.

Low concentrations of TPH (less than 100 μg/g) were detected in two of the six surface soil samples collected during the supplemental EI field program in the Building 39 Area (Table 4-6). Several of the PAHs detected in soil boring samples were detected in surface soil sample SS-08. One of these PAHs, pyrene, also was detected in surface soil sample SS-06. Concentrations did not exceed those detected in the soil boring samples. Concentrations of metals were similar to levels detected in the background soil samples.

Table 4-5 Summary of Building 39 Area Soil Boring Sample Detections (Page 1 of 2)

Site ID	SB-28	SB-28	SB-29	SB-29	SB-29(D)	SB-29	SB-29	SB-31	SB-31
Sample Interval (ft)	0.0-0.5	0.5-5.0	9.7-9.9	14.0-18.7	14.0-18.7	19.0-21.1	24.0-26.6	0.0-0.5	0.5-3.2
Sample Date	10/01/91	10/01/91	10/02/91	10/02/91	10/02/91	10/02/91	10/02/91	10/08/91	10/08/91
ORGANICS (units in µg/g)									
Acenaphthene	NR	<0.033	<0.033	<0.033	<0.033	<0.033	<0.033	NR	0.057
Acetone	NR	<0.046	<0.046	0.051	<0.046	0.049	<0.046	NR	<0.046
Benzo(a)anthracene	NR	0.18	<0.033	<0.033	<0.033	<0.033	<0.033	NR	<0.033
Benzo(a)pyrene	NR	0.26	<0.033	<0.033	<0.033	<0.033	<0.033	NR	0.075
Benzo(b)fluoranthene	NR	0.14	<0.033	<0.033	<0.033	<0.033	<0.033	NR	<0.033
Benzo(k)fluoranthene	NR	0.22	<0.033	<0.033	<0.033	<0.033	<0.033	NR	<0.033
Bis(2-ethylhexyl) phthalate	NR	<0.39	<0.39	<0.39	<0.39	<0.39	0.68*	NR	<0.39
Dibenz(a,h)anthracene	NR	0.067	<0.033	<0.033	<0.033	<0.033	<0.033	NR	<0.033
Diethyl phthalate	NR	<0.19	<0.19	<0.19	<0.19	<0.19	<0.19	NR	0.44*
Di-N-butyl phthalate	NR	3.5*	<0.92	2.4*	4.4	<0.92	2.1*	NR	<0.92
Fluoranthene	NR	0.35	<0.085	<0.085	<0.085	<0.085	<0.085	NR	0.16
Indeno[1,2,3-C,D] pyrene	NR	0.18	<0.033	<0.033	<0.033	<0.033	<0.033	NR	0.060
Phenanthrene	NR	0.091	<0.033	<0.033	<0.033	<0.033	<0.033	NR	0.14
Pyrene	NR	0.28	<0.033	<0.033	<0.033	<0.033	<0.033	NR	0.14
Total Petroleum Hydrocarbons	40	<10	70	100	<10	10	60	20	500[1]

NR = not requested
µg/g = parts per million
< = less than detection limit or certified reporting limit
D = duplicate sample
[1] - dilution factor of 2
[2] - dilution factor of 200
[3] - dilution factor of 10
[4] - dilution factor of 100
[5] - dilution factor of 3
* - also detected in the method blank for this lot and can be qualified as ubiquitous or a lab contaminant (Section 4.1.2)

Table 4-5 Summary of Building 39 Area Soil Boring Sample Detections (Page 2 of 2)

Site ID	SB-28	SB-28	SB-29	SB-29	SB-29(D)	SB-29	SB-29	SB-31	SB-31
Sample Interval (ft)	0.0-0.5	0.5-5.0	9.7-9.9	14.0-18.7	14.0-18.7	19.0-21.1	24.0-26.6	0.0-0.5	0.5-3.2
Sample Date	10/01/91	10/01/91	10/02/91	10/02/91	10/02/91	10/02/91	10/02/91	10/08/91	10/08/91
INORGANICS (units in μg/g)									
Aluminum	14,000[2]	15,000[4]	15,000[2]	16,000[2]	15,000[2]	14,000[2]	12,000[4]	16,000[2]	13,000[2]
Arsenic	4.38	4.06	4.98	7.02	8.02	14[1]	1.94	6.32	4.84
Barium	<190[2]	130[4]	<190[2]	<190[2]	<190[2]	<190[2]	<96[4]	<190[2]	<190[2]
Calcium	83,000[2]	49,000[4]	79,000[2]	85,000[2]	80,000[2]	86,000[2]	37,000[4]	100,000[2]	66,000[2]
Iron	17,000[2]	18,000[4]	18,000[2]	21,000[2]	21,000[2]	20,000[2]	17,000[4]	20,000[2]	17,000[2]
Lead	83[3]	14[1]	19[5]	20[5]	13[5]	11.1	6.71	34[3]	96[3]
Magnesium	12,000[2]	9,100[4]	16,000[2]	15,000[2]	16,000[2]	14,000[2]	13,000[4]	14,000[2]	9,400[2]
Manganese	760[2]	680[4]	<400[2]	570[2]	<400[2]	<400[2]	400[4]	910[2]	810[2]
Mercury	0.055	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027	<0.027

NR = not requested
μg/g = parts per million
< = less than detection limit or certified reporting limit
D = duplicate sample
1 - dilution factor of 2
2 - dilution factor of 200
3 - dilution factor of 10
4 - dilution factor of 100
5 - dilution factor of 3
* - also detected in the method blank for this lot and can be qualified as ubiquitous or a lab contaminant (Section 4.1.2)

Table 4-6 Summary of Building 39 Area Surface Soil Sample Detections

Site ID	SS-03	SS-04	SS-04(D)	SS-05	SS-06	SS-07	SS-08
Sample Interval (ft)	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
Sample Date	7/15/92	7/15/92	7/15/92	7/15/92	7/15/92	7/15/92	7/15/92
ORGANICS (units in µg/g)							
Benzo(a)anthracene	<0.033	<0.033	<0.033	<0.033	<0.033	<0.033	0.055
Benzo(a)pyrene	<0.033	<0.033	<0.033	<0.033	<0.033	<0.033	0.076
Benzo(b)fluoranthene	<0.033	<0.033	<0.033	<0.033	<0.033	<0.033	0.067
Benzo(k)fluoranthene	<0.033	<0.033	<0.033	<0.033	<0.033	<0.033	0.11
Phenanthrene	<0.033	<0.033	<0.033	<0.033	<0.033	<0.033	0.051
Pyrene	<0.033	<0.033	<0.033	<0.033	0.041	<0.033	0.12
Total Petroleum Hydrocarbons	<10	<10	<10	<10	<10	30	50
INORGANICS (units in µg/g)							
Aluminum	12,000^{1}	17,000^{1}	13,000^{1}	16,000^{1}	13,000^{1}	15,000^{1}	9,300^{5}
Arsenic	4.13	3.90	4.13	6.00	5.35	5.67	4.82
Barium	145	139	152	170	103	167	83.2
Beryllium	1.03	1.43	1.12	1.30	1.03	1.10	1.06
Cadmium	1.27	1.49	1.30	1.03	1.20	1.15	0.949
Calcium	110,000^{2}	59,000^{3}	71,000^{2}	92,000^{2}	77,000^{2}	100,000^{2}	>50,000^{3}
Chromium	36.6	35.7	31.2	36.1	33.7	37.0	26.9
Cobalt	16.5	20.9	18.1	21.0	17.4	20.6	13.6
Copper	25.9	30.8	33.1	23.3	25.6	26.7	27.0
Iron	15,000^{1}	21,000^{3}	15,000^{1}	19,000^{1}	16,000^{1}	20,000^{1}	12,000^{5}
Lead	36^{3}	53^{3}	54^{3}	19^{4}	40^{3}	34^{3}	52^{3}
Magnesium	8,100^{1}	9,600^{1}	8,300^{1}	9,500^{1}	25,000^{2}	10,000^{1}	9,600^{5}
Manganese	571	665	667	860	514	769	380
Mercury	<0.027	0.044	0.040	<0.027	0.062	<0.027	0.047
Nickel	19.0	23.2	21.7	23.7	24.9	23.0	16.6
Potassium	3,060	4,620	3,250	4,370	3,760	3,540	2,190
Silver	1.72	0.843	0.835	1.62	1.25	1.52	1.23
Sodium	<44.8	200	183	<44.8	83.2	<44.8	113
Thallium	76.4	79.3	62.5	86.9	64.8	85.3	59.6
Vanadium	23.1	29.1	23.0	25.7	23.7	26.8	19.4
Zinc	72.9	89.7	88.2	70.0	74.2	81.8	84.1

µg/g = parts per million
< = less than detection limit or certified reporting limit
D = duplicate sample
^{1} - dilution factor of 3
^{2} - dilution factor of 20
^{3} - dilution factor of 10
^{4} - dilution factor of 5
^{5} - dilution factor of 2

4.4 SOUTHEAST FENCE LINE AREA

During the initial EI field program, four shallow borings (less than 5 ft bgs) were drilled in the Southeast Fence Line Area, and two samples were analyzed from each boring. The samples from each boring included a surface soil sample (0 to 0.5 ft bgs) and a composite sample from 0.5 ft bgs to the total depth of the boring. An additional surface soil sample was collected during the initial EI field program. All soil samples from 0 to 0.5 ft bgs were analyzed for TPH, metals, and cyanide. Samples collected below 0.5 ft bgs were also analyzed for VOCs and SVOCs.

Thirteen of the surface soil samples collected from the Southeast Fence Line Area during the supplemental EI field program were located near three of these borings (SB-25, SB-26, SB-27) (Figure 3-2). An additional investigative surface soil sample (SS-18) was collected near the southwest boundary of the Southeast Fence Line Area (Figure 3-3). All of these samples were collected from 0.0 to 0.5 ft bgs and analyzed for SVOCs, TPH, and metals.

Several SVOCs were detected in samples from borings SB-26 and SB-27, which were located downslope from the paved drum and fuel storage area near Building 132 (Table 4-7). The SVOCs primarily included PAHs and phthalates. Two detected analytes, 1-methylnaphthalene and naphthalene, are chemically classified as bicyclic aromatic hydrocarbons; however, due to their similarities to the PAHs, the bicyclic aromatic hydrocarbons and PAHs will be collectively referred to as PAHs in this report. Methylene chloride and some of the phthalates detected in samples from these two borings are considered to be laboratory contaminants. The PAH detected at the highest concentration in boring SB-26 was benzo(b)fluoranthene (0.076 μg/g). In boring SB-27, benzo(b)fluoranthene and pyrene were the PAHs detected at the highest concentrations (0.25 μg/g). In borings SB-24 and SB-25, which were located near drainages from the retained area, di-N-butyl phthalate was the only SVOC detected. TPH were reported in all of the soil boring samples, in concentrations ranging from 10 μg/g in surface sample location SS-01 to 6,000 μg/g in the surface soil sample from SB-26. Concentrations of TPH above 500 μg/g were detected in all four samples from borings SB-26 and SB-27 and in the surface soil sample from boring SB-25. All other TPH concentrations in the soil boring samples were less than 50 μg/g.

In the soil boring samples, metals detected at concentrations that were higher than twice the maximum concentrations detected in background samples included zinc, detected from 410 to 1,100 μg/g in samples

Table 4-7 Summary of Southeast Fence Line Area Soil Boring Sample Detections (Page 1 of 2)

Site ID	SB-24	SB-24	SB-25	SB-25	SB-26	SB-26	SB-27	SB-27
Sample Interval (ft)	0.0-0.5	0.5-1.0	0.0-0.5	0.5-4.0	0.0-0.5	0.5-3.4	0.0-0.5	0.5-3.0
Sample Date	10/03/91	10/03/91	10/03/91	10/03/91	10/07/91	10/07/91	10/07/91	10/07/91
ORGANICS (units in μg/g)								
1-Methylnaphthalene**	NR	<0.033	NR	<0.033	NR	0.055	NR	<0.033
Benzo(a)anthracene	NR	<0.033	NR	<0.033	NR	<0.033	NR	0.15
Benzo(a)pyrene	NR	<0.033	NR	<0.033	NR	0.044	NR	0.19
Benzo(b)fluoranthene	NR	<0.033	NR	<0.033	NR	0.076	NR	0.25
Butylbenzyl phthalate	NR	<0.033	NR	<0.033	NR	<0.033	NR	0.27
Benzo(k)fluoranthene	NR	<0.033	NR	<0.033	NR	<0.033	NR	0.049
Diethyl phthalate	NR	<0.19	NR	<0.19	NR	<0.19	NR	0.34*
Di-N-butyl phthalate	NR	2.6	NR	1.9	NR	1.5*	NR	1.7*
Fluoranthene	NR	<0.085	NR	<0.085	NR	<0.085	NR	0.22
Indeno[1,2,3-C,D] pyrene	NR	<0.033	NR	<0.033	NR	<0.033	NR	0.097
Methylene chloride	NR	<0.040	NR	<0.040	NR	0.075*	NR	<0.040
Naphthalene	NR	<0.033	NR	<0.033	NR	0.053	NR	0.041
Phenananthrene	NR	<0.033	NR	<0.033	NR	0.050	NR	0.040
Pyrene	NR	<0.033	NR	<0.033	NR	0.045	NR	0.25
Total Petroleum Hydrocarbons	30	20	600[1]	20	6,000[2]	1,000[3]	900[2]	700[2]

μg/g = parts per million
NR = not requested
< = less than certified reporting limit or detection limit
* - also detected in the method blank for this lot and can be qualified as ubiquitous or a lab contaminant (Section 4.1.2).
** - not a target compound, but is an isomer of target compound 2-methylnaphthalene, which was not analyzed (Section 3.2.2).

1 - dilution factor of 2
2 - dilution factor of 20
3 - dilution factor of 10
4 - dilution factor of 200
5 - dilution factor of 400
6 - dilution factor of 4
7 - dilution factor of 100
8 - dilution factor of 50

Table 4-7 Summary of Southeast Fence Line Area Soil Boring Boring Sample Detections (Page 2 of 2)

Site ID	SB-24	SB-24	SB-25	SB-25	SB-26	SB-26	SB-27	SB-27
Sample Interval (ft)	0.0-0.5	0.5-1.0	0.0-0.5	0.5-4.0	0.0-0.5	0.5-3.4	0.0-0.5	0.5-3.0
Sample Date	10/03/91	10/03/91	10/03/91	10/03/91	10/07/91	10/07/91	10/07/91	10/07/91
INORGANICS (units in µg/g)								
Aluminum	7,600[4]	5,000[4]	8,600[7]	8,900[7]	9,600[7]	12,000[7]	11,000[7]	12,000[7]
Arsenic	4.60	4.03	3.93	4.02	7.19	5.14	11.6	6.36
Barium	<190[4]	<190[4]	110[7]	<96[7]	140[7]	160[7]	150[7]	<96[7]
Calcium	150,000[4]	130,000[5]	63,000[4]	47,000[7]	44,000[7]	45,000[7]	62,000[4]	40,000[7]
Chromium	<130[4]	<130[4]	<67[7]	<67[7]	<67[7]	<67[7]	150[7]	<67[7]
Iron	12,000[4]	8,400[4]	12,000[7]	12,000[7]	14,000[7]	21,000[7]	20,000[7]	15,000[7]
Lead	34[8]	5.55	42[3]	15[6]	290[7]	120[3]	320[8]	68[3]
Magnesium	<7,400[4]	9,800[4]	8,200[7]	9,900[7]	7,800[7]	7,300[7]	12,000[7]	7,300[7]
Manganese	<400[4]	<400[4]	380[7]	330[7]	450[7]	660[7]	500[7]	520[7]
Mercury	<0.027	<0.027	0.038	<0.027	0.034	0.151	0.036	0.200
Zinc	<390[4]	<390[4]	<190[7]	<190[7]	410[7]	780[7]	1,100[7]	<190[7]

µg/g = parts per million
NR = not requested
< = less than certified reporting limit or detection limit
* - also detected in the method blank for this lot and can be qualified as ubiquitous or a lab contaminant (Section 4.1.2).
** - not a target compound, but is an isomer of target compound 2-methylnaphthalene, which was not analyzed (Section 3.2.2).

1 - dilution factor of 2
2 - dilution factor of 20
3 - dilution factor of 10
4 - dilution factor of 200
5 - dilution factor of 400
6 - dilution factor of 4
7 - dilution factor of 100
8 - dilution factor of 50

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from borings SB-26 and SB-27; mercury, detected at 0.200 μg/g in the 0.5 to 3.0 ft bgs sample from SB-27 and at 0.151 μg/g in the 0.5 to 3.4 ft bgs sample from SB-26; lead, detected in SB-26 at 290 μg/g (0.0 to 0.5 ft bgs) and in SB-27 at 320 μg/g (0.0 to 0.5 ft bgs); and chromium, detected at 150 μg/g in the surface soil sample from SB-27. Concentrations of other metals in the soil boring samples were near the ranges detected in background soil samples.

PAHs were detected in all the surface soil samples collected during the supplemental EI field investigation in the Southeast Fence Line Area, with the exception of samples SS-10 and SS-13 (which were collected from the north and west boundaries of the area investigated near Building 132), SS-19 (collected downslope from the drainage ditch), and SS-18 (collected near the southwest boundary of the Southeast Fence Line Area) (Table 4-8). In general, the highest concentrations of PAHs were detected in surface soil sample SS-20, which was collected from soil in the concrete drainage ditch. Fluoranthene was at the highest concentration, 0.37 μg/g. Bis(2-ethylhexyl)phthalate was detected in surface soil sample SS-13. The highest TPH concentration was 2,000 μg/g, in surface soil sample SS-12. Other TPH concentrations above 100 μg/g were detected in surface soil samples SS-09 (400 μg/g), SS-11 (200 μg/g), and SS-22 (200 μg/g). Concentrations of metals were near the range of concentrations detected in Fort Douglas background soils, with the exceptions of lead, detected in sample SS-17 at 320 μg/g; mercury, detected between 0.142 μg/g and 0.285 μg/g in samples SS-12, SS-14, SS-15, SS-16, SS-17, and SS-21; and silver, detected at a concentration of 14 μg/g in sample SS-14. All of these metals were detected at concentrations higher than twice the maximum concentration detected in the background soil samples.

4.5 STORAGE YARD

Four composite samples were collected from the boring drilled downgradient of the storage yard. These samples were analyzed for TPH, SVOCs, VOCs, metals, and cyanide. A surface soil sample was collected nearby and was analyzed for TPH, metals, and cyanide.

TPH was measured at 60 μg/g in SS-02 and 20 μg/g in the 0.5 to 5.0 ft bgs sample from boring SB-30 (Table 4-9). Di-N-butyl phthalate, interpreted to be a result of laboratory method contamination, was reported from 2.0 to 6.0 μg/g in three of the four samples from SB-30. Pyrene was detected at a concentration of 0.080 μg/g in the 0.5 to 5.0 ft bgs sample from this boring. Metals concentrations were similar to levels measured in the background soils.

Table 4-8 Summary of Southeast Fence Line Area Surface Soil Sample Detections (Page 1 of 4)

Site ID	SS-01	SS-09	SS-10	SS-11	SS-12	SS-12(D)	SS-13	SS-14
Sample Interval (ft)	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
Sample Date	10/04/91	7/15/92	7/15/92	7/15/92	7/15/92	7/15/92	7/15/92	7/15/92
ORGANICS (units in µg/g)								
2-Methylnaphthalene	NR	0.090	<0.033	0.049	0.076	0.073	<0.033	0.14
Benzo(a)anthracene	NR	<0.033	<0.033	<0.033	<0.2[4]	<0.2[4]	<0.033	0.057
Benzo(a)pyrene	NR	<0.033	<0.033	<0.033	<0.2[4]	<0.2[4]	<0.033	0.054
Benzo(b)fluoranthene	NR	<0.033	<0.033	<0.033	<0.2[4]	<0.2[4]	<0.033	<0.033
Bis(2-ethylhexyl)phthalate	NR	<0.39	<0.39	<0.39	<2[4]	<2[4]	0.58	<0.39
Benzo(k)fluoranthene	NR	<0.033	<0.033	<0.033	<0.2[4]	<0.2[4]	<0.033	0.058
Fluoranthene	NR	<0.085	<0.085	<0.085	<0.4[4]	<0.4[4]	<0.085	<0.085
Indeno[1,2,3-C,D] pyrene	NR	<0.033	<0.033	<0.033	<0.2[4]	<0.2[4]	<0.033	<0.033
Naphthalene	NR	0.074	<0.033	0.037	0.061	0.059	<0.033	0.12
Phenanthrene	NR	0.060	<0.033	0.046	0.041	<0.2[4]	<0.033	0.058
Pyrene	NR	<0.033	<0.033	0.088	<0.2[4]	<0.2[4]	<0.033	0.087
Total Petroleum Hydrocarbons	10	400	70	200	2,000	2,000	60	30

D = duplicate sample
NR = not requested
µg/g = parts per million
< = less than certified reporting limit or detection limit
[1] - dilution factor of 200
[2] - dilution factor of 4
[3] - dilution factor of 10
[4] - dilution factor of 5
[5] - dilution factor of 20
[6] - dilution factor of 50
[7] - dilution factor of 3
[8] - dilution factor of 2

Table 4-8 Summary of Southeast Fence Line Area Surface Soil Sample Detections (page 2 of 4)

Site ID	SS-15	SS-16	SS-17	SS-18	SS-19	SS-20	SS-21	SS-22
Sample Interval (ft)	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
Sample Date	7/15/92	7/15/92	7/16/92	7/16/92	7/16/92	7/16/92	7/16/92	7/16/92
ORGANICS (units in μg/g)								
2-Methylnaphthalene	0.078	0.052	0.11	<0.033	<0.033	<0.033	0.16	<0.033
Benzo(a)anthracene	<0.033	<0.033	0.071	<0.033	<0.033	0.16	<0.033	0.071
Benzo(a)pyrene	<0.033	<0.033	0.075	<0.033	<0.033	0.14	<0.033	0.069
Benzo(b)fluoranthene	<0.033	<0.033	0.11	<0.033	<0.033	0.19	<0.033	0.12
Bis(2-ethylhexyl)phthalate	<0.39	<0.39	<0.39	<0.39	<0.39	<0.39	<0.39	<0.39
Benzo(k)fluoranthene	<0.033	<0.033	0.042	<0.033	<0.033	0.11	<0.033	0.053
Fluoranthene	<0.085	<0.085	<0.085	<0.085	<0.085	0.37	<0.085	0.11
Indeno[1,2,3-C,D] pyrene	<0.033	<0.033	<0.033	<0.033	<0.033	0.049	<0.033	<0.033
Naphthalene	0.060	0.043	0.073	<0.033	<0.033	<0.033	0.095	<0.033
Phenanthrene	0.038	<0.033	0.065	<0.033	<0.033	0.17	0.048	<0.033
Pyrene	0.067	<0.033	0.073	<0.033	<0.033	0.30	<0.033	0.099
Total Petroleum Hydrocarbons	50	20	90	30	<10	90	10	200

D = duplicate sample
NR = not requested
μg/g = parts per million
< = less than certified reporting limit or detection limit
1 - dilution factor of 200
2 - dilution factor of 4
3 - dilution factor of 10
4 - dilution factor of 5
5 - dilution factor of 20
6 - dilution factor of 50
7 - dilution factor of 3
8 - dilution factor of 2

Table 4-8 Summary of Southeast Fence Line Area Surface Soil Sample Detections (page 3 of 4)

Site ID	SS-01	SS-09	SS-10	SS-11	SS-12	SS-12(D)	SS-13	SS-14
Sample Interval (ft)	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
Sample Date	10/04/91	7/15/92	7/15/92	7/15/92	7/15/92	7/15/92	7/15/92	7/15/92
INORGANICS (units in µg/g)								
Aluminum	5,400[1]	11,000[7]	8,300[7]	12,000[7]	13,000[7]	9,400[8]	9,400[7]	15,000[4]
Arsenic	3.55	4.89	6.32	7.02	4.22	5.06	6.55	6.09
Barium	<190[1]	118	121	143	191	175	96.8	199
Beryllium	<100[1]	1.09	1.04	0.884	1.08	0.929	0.828	1.21
Cadmium	<100[1]	1.72	0.667	2.21	1.40	1.29	0.801	1.53
Calcium	89,000[1]	65,000[5]	48,000[3]	85,000[5]	33,000[3]	>50,000[3]	94,000[5]	39,000[3]
Chromium	<130[1]	29.9	22.6	33.2	24.4	25.6	31.2	27.2
Cobalt	<130[1]	15.0	15.5	16.4	16.7	13.9	14.4	18.8
Copper	<190[1]	36.3	44.9	47.7	33.9	35.6	24.8	37.2
Iron	8,400[1]	13,000[7]	14,000[7]	16,000[7]	16,000[7]	13,000[3]	14,000[7]	19,000[4]
Lead	23[2]	71[3]	52[4]	90[3]	150[5]	170[5]	70[3]	120[5]
Magnesium	10,000[1]	7,400[7]	8,300[7]	8,900[7]	6,600[7]	5,900[8]	9,100[7]	6,500[4]
Manganese	<400[1]	471	386	656	669	594	443	645
Mercury	<0.027	0.085	0.101	0.077	0.142	0.152	<0.027	0.285
Nickel	<310[1]	16.9	17.8	18.2	17.3	15.3	17.5	17.7
Potassium	<24,000[1]	2,800	2,060	2,790	3,530	2,910	2,610	3,730
Silver	<100[1]	1.14	0.891	1.65	0.715	1.09	1.34	14.0
Sodium	<9,000[1]	203	110	109	198	108	<44.8	313
Thallium	<2,900[1]	56.0	68.5	68.4	64.4	59.7	57.3	81.2
Vanadium	<350[1]	21.7	16.6	21.5	24.1	17.7	20.5	24.9
Zinc	<390[1]	121	72.2	173	177	158	77.7	129

D = duplicate sample
< = less than certified reporting limit or detection limit
> = greater than certified reporting limit
[1] - dilution factor of 200
[2] - dilution factor of 4
[3] - dilution factor of 10
[4] - dilution factor of 5

NR = not requested
µg/g = parts per million
[5] - dilution factor of 20
[6] - dilution factor of 50
[7] - dilution factor of 3
[8] - dilution factor of 2

Table 4-8 Summary of Southeast Fence Line Area Surface Soil Sample Detections (page 4 of 4)

Site ID	SS-15	SS-16	SS-17	SS-18	SS-19	SS-20	SS-21	SS-22
Sample Interval (ft)	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5	0.0-0.5
Sample Date	7/15/92	7/15/92	7/16/92	7/16/92	7/16/92	7/16/92	7/16/92	7/16/92
INORGANICS (units in μg/g)								
Aluminum	13,000^{7}	12,000^{7}	8,300^{8}	6,400^{8}	5,500^{8}	5,700^{8}	8,200^{8}	8,600^{7}
Arsenic	3.94	4.03	4.68	6.20	5.20	3.15	3.86	6.70
Barium	155	146	174	80.0	66.6	77.9	141	138
Beryllium	1.18	1.12	0.904	0.819	0.575	0.575	0.907	0.903
Cadmium	1.30	1.18	1.18	0.864	<0.515	1.24	0.902	1.77
Calcium	33,000^{3}	33,000^{3}	49,000^{5}	>100,000^{5}	60,000^{5}	58,000^{5}	42,000^{3}	71,000^{5}
Chromium	26.2	23.8	21.6	29.9	21.3	22.0	19.9	29.6
Cobalt	17.8	15.4	12.5	10.5	11.6	10.1	11.8	15.7
Copper	29.9	26.6	31.2	19.8	29.1	16.4	23.4	42.1
Iron	16,000^{7}	14,000^{7}	11,000^{8}	7,900^{8}	8,300^{8}	7,000^{8}	9,300^{8}	12,000^{7}
Lead	83^{3}	92^{3}	320^{6}	55^{3}	10^{4}	45^{3}	61^{3}	130^{5}
Magnesium	6,600^{7}	6,300^{7}	5,800^{8}	6,000^{8}	9,400^{8}	7,200^{8}	6,200^{8}	8,900^{7}
Manganese	592	554	451	414	227	268	435	512
Mercury	0.201	0.220	0.216	0.062	<0.027	<0.027	0.151	0.072
Nickel	18.2	17.8	13.5	12.5	15.1	13.9	13.6	20.9
Potassium	3,590	3,580	2,800	1,660	1,410	1,270	2,280	2,130
Silver	0.758	0.747	0.589	1.56	0.598	0.672	<0.521	0.851
Sodium	264	196	302	<44.8	51.5	99.3	172	123
Thallium	64.9	66.5	43.5	30.6	39.4	39.9	42.9	54.0
Vanadium	25.5	21.4	16.7	14.5	12.6	12.8	16.1	20.2
Zinc	97.8	89.1	114	70.8	31.0	57.6	66.2	133

D = duplicate sample
< = less than certified reporting limit or detection limit
> = greater than certified reporting limit
1 - dilution factor of 200
2 - dilution factor of 4
3 - dilution factor of 10
4 - dilution factor of 5

NR = not requested
μg/g = parts per million

5 - dilution factor of 20
6 - dilution factor of 50
7 - dilution factor of 3
8 - dilution factor of 2

Table 4-9 Summary of Soil Sample Detections, Downgradient of Storage Yard

Site ID	SS-02	SB-30	SB-30	SB-30	SB-30
Sample Interval (ft)	0.0-0.5	0.5-5.0	5.0-9.5	15.0-20.0	25.0-25.8
Sample Date	10/04/91	10/01/91	10/01/91	10/01/91	10/01/91
ORGANICS (units in $\mu g/g$)					
Di-N-butyl phthalate	NR	<0.92	2.0*	6.0*	3.9*
Pyrene	NR	0.080	<0.033	<0.033	<0.033
Total Petroleum Hydrocarbons	60	20	<10	<10	<10
INORGANICS (units in $\mu g/g$)					
Aluminum	12,000[1]	11,000[3]	11,000[3]	9,800[4]	13,000[3]
Arsenic	6.98	1.33	2.51	2.55	2.42
Barium	<190[1]	<96[3]	<96[3]	<380[4]	160[3]
Calcium	63,000[1]	73,000[1]	72,000[1]	60,000[4]	36,000[3]
Iron	16,000[1]	16,000[3]	15,000[3]	13,000[4]	17,000[3]
Lead	20[2]	4.47	5.15	6.24	6.06
Magnesium	10,000[1]	18,000[3]	18,000[3]	<15,000[4]	12,000[3]
Manganese	460[1]	510[3]	590[3]	<800[4]	720[3]

NR = not requested
$\mu g/g$ = parts per million
< = less than detection limit or certified reporting limit
[1] - dilution factor of 200
[2] - dilution factor of 4
[3] - dilution factor of 100
[4] - dilution factor of 400
* - also detected in the method blank for this lot and can be qualified as ubiquitous or a lab contaminant (Section 4.1.2)

4.6 Soil Organic Unknowns

Organic unknowns are identified using GC/MS. GC/MS target compounds are compared against known standards and are reported semi-quantitatively. Peaks other than target analytes can be identified by comparing their respective mass spectra to the National Institute of Standard Technology (NIST) spectral library. A spectra library search is performed and a tentative identification and estimated concentration is obtained through comparison with the analytical internal standard. The reporting difference is represented by only one significant figure (USATHAMA, 1990).

The unknown compound is identified by an "unk" number. This number is related to the retention time of the internal standard, divided into the unknown's retention time, and multiplied by 100, for a volatile unknown. If the unknown is a volatile compound, the "unk" numbering system will be below 500. Semivolatile unknowns are identified by an "unk" number above 500. The semivolatile retention time is calculated the same as volatile retention times except that 500 is added to distinguish the semi-volatiles from the volatiles as described below:

$$\frac{8.7}{15.5}\ \mathit{minutes} \times 100 = \mathit{UNK056}$$

These unknown numbers are not given a corresponding name in the IRDMIS database. The "unk" numbers are used only to identify trends of unknown or nontarget analytes that are being detected at a site (USATHAMA, 1990).

The "unk" numbers and estimated concentrations are included in Appendix G. Unknowns were detected in all soil samples and associated rinse and trip blank samples analyzed by GC/MS. For the initial EI program samples, approximately 80 percent of the detections were semivolatiles and the remaining 20 percent were volatiles. Approximately 50 percent of these compounds were tentatively identified and can be categorized as follows: (1) hydrocarbons typically derived from plant material, (2) unknown hydrocarbons that may be site-related or naturally occurring, and (3) unknown phthalates. Phthalates are ubiquitous and are often laboratory derived. Approximately one-half of the volatiles were detected in the rinse and trip blanks. For the supplemental EI program samples, which were all analyzed for semivolatiles by GC/MS, only compounds that could be identified to greater than 95 percent certainty (purity of fit) were provided in accordance with USAEC requirements. Hexadecanoic acid was the only

compound identified, and was detected in two samples. This compound may be derived from plant material.

4.7 TRANSFORMERS

A total of 24 transformers were sampled and analyzed for PCBs. Seven types of PCBs (1016, 1221, 1232, 1242, 1248, 1254, 1260) were analyzed. PCB 1260 was detected in two of the transformer oil samples (Table 4-10). A concentration of 200 μg/g was measured in transformer samples 15-02 and 15-03. No other detections of PCBs above the detection limit of 5 μg/g were reported.

4.8 BUILDINGS

Lead concentration in paint wipe and paint chip samples is discussed in this section. Radon concentrations measured in the buildings are also summarized.

4.8.1 LEAD

A total of 21 paint chip samples and 32 wipe samples, including one duplicate paint chip sample and one duplicate wipe sample, were collected from 49 structures. Lead was detected in all wipe samples and in all but one of the paint chip samples (64A-001). However, the detection limit for this sample (400 μg/g) was higher than the concentrations detected in four other paint chip samples. Table 4-11 summarizes the detections. Lead concentration in paint chips is given in both μg/g and percent lead by weight. Lead concentration in wipe samples is given in both $\mu g/cm^2$ and $\mu g/ft^2$. The concentrations reported in weight percent and $\mu g/ft^2$ were calculated from laboratory values that were reported in μg/g and $\mu g/cm^2$, respectively, because some exposure concentration standards or guidelines are identified in these units.

Concentrations of lead in the interior paint chips ranged from 20 μg/g in Building 23 (0.002 weight percent) to 400,000 μg/g or 40 percent lead by weight in Building 10B. Lead in the wipe samples was measured from 0.002 $\mu g/cm^2$ (2 $\mu g/ft^2$) in Building 9A to 0.5 $\mu g/cm^2$ (400 $\mu g/ft^2$) in Building 60A (Table 4-11). Lead concentration in exterior paint chip samples was measured at 500 μg/g (0.05 weight percent) in a sample from Building 10B and at 50,000 μg/g (5 weight percent) in a sample from Building 56A.

Table 4-10 Summary of PCB Detections in Transformer Oil

Site ID	Sample Date	PCB 1260
01-01	10/08/91	ND(5)
02-01	10/08/91	ND(5)
02-01(D)	10/08/91	ND(5)
03-01	10/08/91	ND(5)
03-02	10/08/91	ND(5)
03-03	10/08/91	ND(5)
04-01	10/07/91	ND(5)
06-01	10/07/91	ND(5)
06-02	10/07/91	ND(5)
06-03	10/07/91	ND(5)
07-01	10/07/91	ND(5)
08-01	10/07/91	ND(5)
09-01	10/07/91	ND(5)
10-01	10/07/91	ND(5)
10-01(D)	10/07/91	ND(5)
10-02	10/07/91	ND(5)
10-03	10/07/91	ND(5)
11-01	10/07/91	ND(5)
12-01	10/07/91	ND(5)
13-01	10/08/91	ND(5)
13-02	10/08/91	ND(5)
13-03	10/08/91	ND(5)
14-01	10/07/91	ND(5)
14-01(D)	10/07/91	ND(5)
15-01	10/08/91	ND(5)
15-02	10/08/91	200[1]
15-03	10/08/91	200[1]

Units are in $\mu g/g$
$\mu g/g$ = parts per million
D = duplicate sample
[1] - dilution factor of 5
ND(5) - not detected at the detection limit in parenthesis
Note: No other PCBs were detected.

Table 4-11 Summary of Paint Chip and Wipe Detections (Page 1 of 3)

Site ID	Sample Date	Lead Concentration			
		Paint Chip		Wipe	
		μg/g	weight %	μg/cm²	μg/ft²
1B-001	10/03/91	1,000[2]	0.1	-	-
2B-001	10/04/91	-	-	0.2	100
3-001	10/03/91	-	-	0.06	60
4-001	10/04/91	-	-	0.4	300
5-001	10/04/91	7,000[4]	0.7	-	-
6B-001	10/02/91	-	-	0.07	60
7B-001	10/02/91	-	-	0.006	6
8A-001	10/01/91	-	-	0.07	60
8A-001(D)	10/01/91	-	-	0.06	60
9A-001	10/02/91	-	-	0.002	2
10B-001	10/01/91	400,000[1]	40	-	-
10B-001(D)	10/01/91	400,000[1]	40	-	-
10B-002*	10/01/91	500[2]	0.05	-	-
11A-001	10/01/91	-	-	0.1	100
12A-001	10/01/91	-	-	0.09	80
13A-001	10/01/91	-	-	0.08	80
14B-001	10/02/91	-	-	0.01	10
15A-001	10/01/91	-	-	0.07	60
16A-001	10/02/91	-	-	0.03	20
17B-001	10/03/91	-	-	0.06	50
18C-001	10/03/91	-	-	0.2	200
19B-001	10/01/91	30[2]	0.003	-	-
20-001	10/04/91	80,000[2]	8	-	-

[1] - dilution factor of 100
[2] - dilution factor of 2
[3] - dilution factor of 50
[4] - dilution factor of 200
D = duplicate sample
< = less than detection limit
* exterior sample

Note: Conversion of wipe results from μg/cm² to μg/ft² was performed using results in the IRDMIS, not the rounded values reported in this table.

Table 4-11 Summary of Paint Chip and Wipe Detections (Page 2 of 3)

Site ID	Sample Date	Lead Concentration			
		Paint Chip		Wipe	
		μg/g	weight %	μg/cm²	μg/ft²
21-001	10/03/91	-	-	0.02	20
22-001	10/03/91	-	-	0.02	20
23-001	10/03/91	20[2]	0.002	-	-
24-001	10/01/91	-	-	0.04	30
25-001	10/01/91	-	-	0.05	50
31-001	10/03/91	-	-	0.05	40
32-001	10/02/91	300,000[3]	30	-	-
37-001	10/04/91	90,000[2]	9	-	-
39-004	10/03/91	30[2]	0.003	-	-
41-001	10/03/91	10,000[2]	1	-	-
S48-001	10/04/91	200,000[3]	20	-	-
49-001	10/04/91	-	-	0.02	20
52-001	10/01/91	-	-	0.02	20
53-001	10/05/91	-	-	0.2	200
54-001	10/04/91	80,000[2]	8	-	-
55-001	10/04/91	7,000[2]	0.7	-	-
56A-001	10/01/91	-	-	0.02	20
56A-002*	10/01/91	50,000[2]	5	-	-
57B-001	10/02/91	-	-	0.01	10
58A-001	10/02/91	400[2]	0.04	-	-
59-001	10/02/91	-	-	0.006	6
60A-001	10/05/91	-	-	0.5	400
61-001	10/03/91	30,000[2]	3	-	-

[1] - dilution factor of 100
[2] - dilution factor of 2
[3] - dilution factor of 50
[4] - dilution factor of 200
D = duplicate sample
< = less than detection limit
* exterior sample
Note: Conversion of wipe results from μg/cm² to μg/ft² was performed using results in the IRDMIS, not the rounded values reported in this table.

Table 4-11 Summary of Paint Chip and Wipe Detections (Page 3 of 3)

Site ID	Sample Date	Lead Concentration			
		Paint Chip		Wipe	
		$\mu g/g$	weight %	$\mu g/cm^2$	$\mu g/ft^2$
62-001	10/02/91	-	-	0.02	20
63-001	10/02/91	-	-	0.03	20
64A-001	10/02/91	<400[4]	<0.04	-	-
65B-001	10/05/91	-	-	0.06	50
66B-001	10/02/91	40,000[2]	4	-	-
350-001	10/04/91	200[2]	0.02	-	-
351-001	10/04/91	-	-	0.004	4

[1] - dilution factor of 100
[2] - dilution factor of 2
[3] - dilution factor of 50
[4] - dilution factor of 200
D = duplicate sample
< = less than detection limit
* exterior sample
Note: Conversion of wipe results from $\mu g/cm^2$ to $\mu g/ft^2$ was performed using results in the IRDMIS, not the rounded values reported in this table.

4.8.2 RADON

Radon levels from the long-term monitoring program conducted within the area of Fort Douglas to be excessed ranged from 0.2 pCi/L to 7.2 pCi/L (Table 4-12). Levels above 4.0 pCi/L, the EPA-suggested average long-term exposure limit, were measured using ATMs from four housing units or structures, 10B, 11A, 12A, and 32. Single detectors were placed in 10B, 11A, and 12A; however, levels in adjacent family housing units within the structures (10A, 11B, and 12B) ranged from 3.2 to 3.7 pCi/L. ATMs from three of five locations in Building 32 indicated levels above 4.0 pCi/L. The highest measurement from the short-term program was 4.0 pCi/L, measured in Building 1B. A level of 3.6 pCi/L was measured in this building during the long-term monitoring program.

Table 4-12 Summary of Radon Test Results (Page 1 of 3)

Building Number	Long-Term Program			Short-Term Program		
	Deployment Date	Retrieval Date	Radon (picocuries per liter)	Deployment Date	Retrieval Date	Radon (picocuries per liter)
1A	05/17/89	05/22/90	2.1,2.0	-	-	-
1B	05/17/89	05/22/90	3.6	06/09/89	06/12/89	4.0
2A	05/18/89	05/30/90	1.1	-	-	-
2B	05/22/89	05/14/90	1.6	06/09/89	06/12/89	1.6
3A	05/16/89	05/14/90	0.9	-	-	-
4	05/17/89	05/14/90	1.1	-	-	-
4	05/17/89	05/14/90	1.1	-	-	-
5	05/15/89	05/14/90	1.3,1.4	-	-	-
5	05/15/89	05/14/90	0.9	-	-	-
5	05/15/89	05/14/90	1.0	-	-	-
6A	05/17/89	05/25/90	3.2	-	-	-
6B	05/22/89	05/14/90	2.4	-	-	-
7A	05/17/89	05/21/90	1.5,1.7	-	-	-
7B	05/17/89	05/14/90	1.9	-	-	-
8A	05/17/89	05/14/90	1.4	-	-	-
8B	05/22/89	05/20/90	0.6	-	-	-
9A	05/22/89	05/14/90	1.8	-	-	-
9B	05/30/89	05/22/90	2.9,2.9	-	-	-
10A	06/01/89	05/25/90	3.6,3.7	-	-	-
10B	05/22/89	05/14/90	4.2	-	-	-
11A	05/17/89	05/14/90	7.2	-	-	-
11B	05/17/89	05/25/90	3.2	-	-	-
12A	05/17/89	05/14/90	4.4	-	-	-
12B	05/19/89	05/20/90	3.6	-	-	-
13A	05/17/89	05/22/90	2.3	-	-	-
13B	05/17/89	05/22/90	3.8,3.4	-	-	-
14A	05/17/89	05/14/90	0.7	-	-	-
14B	05/17/89	05/14/90	3.4	-	-	-
15A	06/05/89	05/25/90	1.6	-	-	-
15B	05/17/89	05/14/90	3.1	-	-	-

Table 4-12 Summary of Radon Test Results (Page 2 of 3)

Building Number	Long-Term Program Deployment Date	Long-Term Program Retrieval Date	Long-Term Program Radon (picocuries per liter)	Short-Term Program Deployment Date	Short-Term Program Retrieval Date	Short-Term Program Radon (picocuries per liter)
16A	05/25/89	05/14/90	2.7	-	-	-
16B	05/31/89	05/24/90	3.5	-	-	-
17A	05/22/89	05/14/90	1.4	-	-	-
18A	05/17/89	05/14/90	2.2	-	-	-
18B	06/05/89	05/14/90	1.8	-	-	-
18C	05/17/89	05/14/90	4.0	6/09/89	6/12/89	2.4
19A	05/17/89	05/25/90	2.2	-	-	-
19B	05/17/89	05/30/90	2.9,3.1	-	-	-
19C	05/22/89	05/14/90	2.8	6/09/89	6/12/89	0.6
20	05/18/89	05/30/90	3.5	-	-	-
20	05/18/89	05/30/90	3.5	-	-	-
20	05/18/89	05/30/90	3.2	-	-	-
21	06/06/89	05/14/90	0.9	-	-	-
22	05/19/89	05/30/90	0.7	-	-	-
23	05/24/89	05/23/90	0.6	-	-	-
24	05/22/89	05/30/90	0.8	-	-	-
25	05/19/89	05/14/90	1.0	-	-	-
31	05/18/89	05/15/90	2.0	-	-	-
31	05/18/89	05/15/90	2.1	-	-	-
31	05/18/89	05/15/90	2.4	-	-	-
32	05/16/89	05/15/90	4.5	-	-	-
32	05/16/89	05/15/90	4.3	-	-	-
32	05/16/89	05/15/90	1.3,0.9	-	-	-
32	05/16/89	05/15/90	1.4	-	-	-
32	05/16/89	05/15/90	4.7	-	-	-
48	05/16/89	05/15/90	0.8	-	-	-
48	05/16/89	05/15/90	2.7	-	-	-
48	05/16/89	05/15/90	0.5	-	-	-
48	05/16/89	05/15/90	0.7	-	-	-

Table 4-12 Summary of Radon Test Results (Page 3 of 3)

Building Number	Long-Term Program					
	Deployment Date	Retrieval Date	Radon (picocuries per liter)	Deployment Date	Retrieval Date	Radon (picocuries per liter)
49	05/15/89	05/15/90	2.4	06/09/89	06/12/89	0.4
49	05/15/89	05/15/90	0.2	06/09/89	06/12/89	0.5
52	05/18/89	05/21/90	1.6,1.6	-	-	-
54	05/16/89	05/21/90	1.8	-	-	-
54	05/16/89	05/21/90	0.9	-	-	-
54	05/16/89	05/21/90	0.9	-	-	-
54	05/16/89	05/21/90	0.9	-	-	-
55	05/19/89	05/21/90	1.3,1.2	-	-	-
56B	05/19/89	05/19/90	1.4	-	-	-
57A	05/22/89	05/25/90	1.7	-	-	-
57B	05/19/89	05/15/90	2.7,2.7	-	-	-
58A	05/18/89	05/15/90	0.6	-	-	-
58B	05/18/89	05/15/90	1.0	-	-	-
59	06/02/89	05/15/90	0.6	-	-	-
60A	05/22/89	05/21/90	1.5	-	-	-
60B	05/18/89	05/21/90	0.9	-	-	-
61	05/18/89	05/15/90	1.3	-	-	-
62	06/01/89	05/30/90	1.2	-	-	-
63	05/18/89	05/15/90	1.1,1.1	-	-	-
64A	05/18/89	05/21/90	1.0	-	-	-
64B	05/18/89	05/15/90	2.2	-	-	-
65A	05/22/89	05/20/90	0.6	-	-	-
65B	05/22/89	05/21/90	1.8	06/09/89	06/12/89	2.0
66A	05/18/89	05/15/90	1.1	-	-	-
66B	05/18/89	05/15/90	1.4,1.4	-	-	-
350	05/19/89	05/18/90	0.2	-	-	-
351	05/19/89	05/18/90	1.6	-	-	-

5.0 CONTAMINATION ASSESSMENT

In the following sections, an assessment of the analytes detected in each investigated area or medium is presented, based on the summary of the nature and extent presented in Section 4.0. Potential migration pathways of the site-related contaminants also are identified. The migration and attenuation of potential contaminants along a pathway are related to the intrinsic properties of the medium and chemical constituents of concern. Therefore, the factors that influence the chemical breakdown and migration of contaminants detected in soil, buildings, and transformers are discussed. Assessment of contaminant migration is based on the potential migration pathways identified and the characteristic degradation, persistence and mobility of the chemicals.

The sources and contaminant migration pathways are summarized in a conceptual site model which also considers the impacts on receptor populations. In Section 6.0, risk to receptor populations is assessed.

5.1 BUILDING 39 AREA

Analytes detected in the Building 39 area included TPH and several semivolatile organics, primarily phthalates and PAHs. Elevated TPH concentrations are often detected by the method used for the soil samples, EPA 418.1 (USEPA, 1983) due to positive interferences (Thomey et al., 1989). Therefore, it is inferred that the reported TPH concentrations may not be an indication of the actual presence of hydrocarbons unless: 1) the concentrations are elevated compared to other samples, 2) hydrocarbons also are detected in the VOC or SVOC analyses, 3) elevated levels of inorganics are detected, and/or 4) staining is noted. Detections of phthalates can be attributed to laboratory contamination and to the ubiquitous nature of phthalates. PAHs detected in the soil samples typically are constituents of oil, gasoline, coal tar, coal, kerosene, diesel, and bitumen.

In the Building 39 Area, a TPH concentration of 500 μg/g and associated PAH detections occurred in a sample that was collected near the north end of the wash rack/oil change/degreasing area, from the 0.5 to 3.2 ft bgs interval of boring SB-31. Minor black stain was noted in the field on the subsurface soil (including concrete) sample from this boring. Metals concentrations were near background levels. The TPH concentration in the surface soil sample was 20 μg/g. Samples deeper than 3.2 ft bgs could not be obtained from this boring due to auger refusal. PAHs and TPH were not detected in the surface soil sample (SS-05) collected adjacent to this boring. Approximately 15 ft southwest of boring SB-31, pyrene

was detected slightly above the CRL in surface soil sample SS-06. No elevated levels of metals or TPH were detected in this sample.

At the south end of the wash rack/oil change/degreasing area, several PAHs were detected in the 0.5 to 5.0 ft bgs sample from boring SB-28 and in surface soil sample SS-08. TPH concentrations in these samples and in the 0.0 to 0.5 ft bgs sample from SB-28 did not exceed 50 μg/g. Boring SB-28 was drilled to a depth of 15 ft bgs; however, in accordance with the SAP, samples deeper than 5 ft bgs were not collected due to the absence of staining and measurable headspace concentrations.

TPH concentrations in the soil samples from the boring (SB-29) drilled to investigate the UST area did not exceed 100 μg/g. The organics detected, phthalates and acetone, are not interpreted to be derived from site-related contamination (as discussed in Section 4.3). Metals were detected near the range of concentrations detected in the background soil samples.

In summary, in the Building 39 area, the source of hydrocarbons to the soil was the wash rack/oil change/degreasing area. Chromatogram fingerprints from GC/MS analysis indicated heavy oils, such as used motor oils or lubricants, were released to the soil at the north and south ends of this area. Hydrocarbons were detected in the deepest sample intervals. Site-related contaminants were not detected in the soil samples collected from the former UST area, therefore, the UST area is not considered a potential source. The results for the UST area confirm the results of the Westech investigation.

5.1.1 Potential Contaminant Migration Pathways

The primary potential migration pathway of hydrocarbons from the wash rack/oil change/degreasing area is leaching into deeper, unsaturated sediments from the soil. The regional ground-water table is approximately 350 ft bgs; migration of contaminants to the regional aquifer is not likely. Shallow ground water was not measured in the borings in this area, although during a previous investigation, 4 to 6 inches of perched ground water were measured (at approximately 25 ft bgs) after completion of a nearby well (DOMW-2; Section 2.0). Based on the limited amount of ground water, migration of contaminants via these perched zones does not appear to be significant. The area is covered by sod; therefore, other pathways-including direct contact with the soil by humans; or the air, surface water, and biota pathways-are not expected to be routes of migration.

5.1.2 CONTAMINANT DEGRADATION/PERSISTENCE/MOBILITY

In the wash rack/oil change/degreasing area, TPH and several site-related PAHs were detected in surface and subsurface soil. Some of the physical and chemical characteristics of these PAHs are shown in Table 5-1. In general, these compounds have low solubilities, high molecular weights, and do not readily react with water (Howard et. al., 1991) or volatilize. Thus, little degradation is expected to occur for these analytes. The octanol/water partition coefficients (Kow) are high (greater than 1,000), indicating these compounds generally are immobile, slowly biodegradable or nonbiodegradable, bioaccumulative, accumulative, persistent, and sorbed in soil (Ney, 1990).

5.1.3 CONTAMINANT MIGRATION

The hydrology of the site, combined with the general immobility of the PAHs, and the vegetative cover indicate that little or no migration of site-related contaminants from the wash rack/oil change/degreasing area is expected to occur. The limited distribution of the hydrocarbons, as shown by the detections in samples from the immediate vicinity of the wash rack/oil change/degreasing area, also supports the supposition that the migration of contaminants is limited.

5.2 SOUTHEAST FENCE LINE AREA

In the Southeast Fence Line Area, four borings and one surface soil location were sampled during the initial EI field program to investigate three potential source areas. Analytical results indicated that two of the source areas potentially released contaminants to the soil. For the supplemental EI field program, additional surface soil samples were collected to investigate these two source areas: the paved drum and fuel storage area near Building 132 and the drainage ditch that may have received runoff from the waste oil USTs near Building 134. In addition, samples were collected to assess the adjacent area that apparently was intermittently used for disposal of post waste.

Analytical results for soil samples from SS-01 and SB-24 indicate that the parking/storage lot area near Building 134 was not a source of contaminants to soil at the outlet of the runoff discharge culvert. TPH concentrations did not exceed 30 μg/g, and di-N-butyl phthalate was the only organic detected. Metals concentrations were near levels detected in the background soils.

Table 5-1 Selected Physical and Chemical Properties of Detected PAHs

Analyte	Solubility (mg/L)[1]	Molecular Weight[2]	Vapor Pressure[3]	Kow[5]
*1-Methylnaphthalene	26-28	142.19		
*2-Methylnaphthalene	25.4	142.19		13,000
**Acenaphthene	3.47	154.21	0.02 torr at 20°C	21,380
Benzo(a)anthracene	0.014	228	5×10^{-9} torr at 20°C	407,380
Benzo(a)pyrene	0.0038	252.30	5×10^{-9} torr at 20°C	1,096,478
Benzo(b)fluoranthene	0.012	252	5×10^{-7} torr at 20°C	3,715,352
Benzo(k)fluoranthene	0.00055	252		6,920,000[6]
**Dibenz(a,h)anthracene	0.0005	278.33		933,000[6]
Fluoranthene	0.26	202	6×10^{-6} torr at 20°C	213,796
Indeno[1,2,3-c,d]pyrene	0.62	276.34		45,700,000[6]
*Naphthalene	34.4	128.16	1 mm Hg (at 53°C)[4]	2,040
Phenanthrene	1.29	178.22	6.8×10^{-4} mm Hg (at 20°C)	32,900; 28,840
Pyrene	0.14	202.24	6.85×10^{-7} torr	$124,000 \pm 11,000$

* - Detected only in Southeast Fence Line Area

** - Detected only in Building 39 Area

[1] - Amount of substance that will readily dissolve in water at 25°C (Walton, 1985; Ney, 1990; Verschueren)

[2] - Sum of the atomic weights in atomic mass units (Budavari et al., 1989; Verschueren, 1983)

[3] - Equilibrium between a liquid and gas (Ney, 1990)

[4] - (Verschueren, 1983)

[5] - Octanol-water partition coefficient (Ney, 1990)

[6] - Calculated from Log Kow (Walton, 1985)

Note: torr = 1 mm Hg at 0°C and sea level (Ney, 1990)

Boring SB-25 and surface soil locations SS-19, SS-20, SS-21, and SS-22 were sampled to investigate potential contaminants in the drainage ditch that may have been released and transported from the waste oil USTs near Building 134. A TPH concentration of 600 μg/g was detected in the surface soil sample (0.0 to 0.5 ft bgs) from boring SB-25. Di-N-butyl phthalate was detected in the deeper sample (0.5 to 4.0 ft bgs), and TPH was reported at a concentration of 20 μg/g. Several PAHs were detected in surface soil samples SS-20, SS-21, and SS-22; concentrations did not exceed 0.4 μg/g. TPH concentrations in these samples ranged up to 200 μg/g. In SS-21, mercury was detected above levels measured in the background soils, at a concentration of 0.151 μg/g. Chromatogram fingerprints from GC/MS analysis indicate the hydrocarbons are primarily heavy oils. The data potentially indicate that the hydrocarbons and mercury may have been transported by surface water from the UST area through the drainage ditch to the surface soil in the Southeast Fence Line Area. However, vertical migration of the contaminants to deeper soils and the lateral distribution of contaminants appear to be limited.

Several PAHs and elevated levels of TPH (700 to 6,000 μg/g) were detected in samples from borings SB-26 and SB-27. These samples were collected to investigate drum and fuel storage areas near Building 132. PAHs were detected in 7 of the 9 surface soil samples collected in the vicinity of these borings. TPH concentrations in the surface soil samples ranged up to 2,000 μg/g (SS-12). The PAHs detected primarily are constituents of gasoline, oil, coal tar, coal, lubricants, kerosene, diesel, and bitumen. Chromatogram fingerprints from GC/MS analysis of the soil indicate that hydrocarbons released to the soil were primarily heavy oils. An additional peak indicative of slightly lighter weight oil was generated by hydrocarbons in soil from boring SB-26. Detections of phthalates and methylene chloride, interpreted to be unrelated to site contamination, were reported in samples from the borings. Metals detections above levels measured in the background soils include zinc (410 to 1,100 μg/g), lead (290 to 320 μg/g), and mercury (0.142 to 0.285 μg/g). Chromium also was detected above background at a concentration of 150 μg/g in the surface soil sample from boring SB-27, and silver was detected above background (14 μg/g) in surface soil sample SS-14. As discussed in Section 3.2.3, surface stains were noted in the vicinity of the drum and fuel storage areas. In addition, used oil filters were on the ground surface near SS-12 and also at another downslope location. Pieces of brick, ceramic, coal, cast-iron pipe, and masonry were recovered from the borings. The hydrocarbons and metals may have been released from some of these materials to the soil, and/or may have been transported by surface water from possible spills or leaks from storage containers in the adjoining storage areas. The borings could not be drilled below a depth of 3.4 ft bgs due to auger refusal. Hydrocarbons and elevated levels of metals were detected in the deepest sampled intervals.

Prior to the use of this area for storage and maintenance operations (circa 1960), a salvage yard and horse stables were located in the vicinity, on the retained area. Based on observations made during the EI field programs (see Section 3.2.3) and subsequent conversations with Jess McCall, curator of the Fort Douglas Military Museum, Fort Douglas post trash (including coal, ceramics, bottles, animal bones, and a rifle casing) was dumped near Red Butte Creek until approximately 1940. (The ceramics and glassware recovered during the EI field investigation were manufactured potentially between 1880 and 1930.) Surface soil sample SS-18 was collected near the southwest edge of the excessed Southeast Fence Line Area to assess potential compounds associated with the coal and other debris found in much of the Southeast Fence Line Area. Debris associated with more recent storage and maintenance operations, such as the used oil filters, were not observed in this portion of the Southeast Fence Line Area. No PAHs were detected in this sample, which was observed to contain coal or coal-like fragments, and TPHs were detected at a concentration of 30 $\mu g/g$. Concentrations of metals were near the ranges detected in the background soil samples. These results indicate that the coal and debris disposed of during the same period are likely not sources of the PAHs and elevated levels of TPH and metals that were detected in other locations in the Southeast Fence Line Area.

5.2.1 POTENTIAL CONTAMINANT MIGRATION PATHWAYS

Contaminated soil in the vicinity of the drainage ditch and downslope of the drum and fuel storage areas could be carried in surface-water runoff and discharged off site to Red Butte Creek. Because PAHs, TPH, and levels of metals above background concentrations also were detected in surface soils in these locations, other potential pathways include direct contact to the soil by humans, and air and biota pathways. Little migration by ground water is expected to occur. As discussed in Section 5.1.1, the regional ground-water table is deep, approximately 350 ft bgs, and only limited amounts of shallow perched ground water have been measured in monitoring wells. Migration to Red Butte Creek via discharge of perched ground water is improbable because in this area, Red Butte Creek loses water to the underlying soils (Section 2.1.5).

5.2.2 CONTAMINANT DEGRADATION/PERSISTENCE/MOBILITY

At the drainage ditch outlet from the Building 134 area, TPH, PAHs, and a mercury concentration above background levels were detected in surface soil, but no elevated levels of these compounds were detected in samples collected deeper than 0.5 ft bgs. Downslope from the paved drum and fuel storage area

adjacent to Building 132, TPH, PAHs, and levels of metals above background were detected in surface and subsurface soil. Eight of the PAHs detected in the Southeast Fence Line Area were the same as those detected in the Building 39 wash rack/oil change/degreasing area. In the Southeast Fence Line Area, 1-methylnaphthalene, 2-methylnaphthalene, and naphthalene additionally were detected, and acenaphthene and dibenz(a,h)anthracene were not detected. Some of the physical and chemical characteristics of all detected PAHs are shown in Table 5-1. In general, these PAHs have low solubilities, high molecular weights, and do not readily react with water or volatilize. Exceptions include naphthalene, 1-methylnaphthalene, and 2-methylnaphthalene, which are moderately soluble and degradable; naphthalene also is semivolatile. The octanol water partition coefficients (Kow) are high (greater than 1,000) for all of these PAHs, indicating these compounds generally are immobile, slowly biodegradable or nonbiodegradable, bioaccumulative, accumulative, persistent, and sorbed in soil (Ney, 1990). Lead, zinc, mercury, chromium, and silver were detected above levels reported in background samples. These metals have low solubility in water, and little chemical breakdown is expected to occur.

5.2.3 CONTAMINANT MIGRATION

A likely transport mechanism for the PAHs, TPH, and mercury detected in the drainage ditch outflow sediments is migration adsorbed to suspended sediment in surface water runoff, since these compounds potentially were transported by surface water to the sample collection locations. Near Building 132, the generally low solubility of the PAHs and metals and the low reactivity of the PAHs indicate a probable transport mechanism of these compounds in surface soil also would be migration of suspended sediment in surface-water runoff. The surface water runoff from both areas could discharge off site to Red Butte Creek. Water in the creek is not used for human consumption, and swimming is prohibited; however, fishing is allowed. Air transport of hydrocarbons sorbed to surface soil particulates also is possible, but likely would be minor because of the vegetative cover and the absence of vehicular traffic. Little migration from subsurface soil near Building 132 is expected to occur because of the low solubilities of the PAHs and metals.

5.3 STORAGE YARD

Analytical results for soil collected from surface soil sample location SS-02 and soil boring location SB-30 indicated potential, investigated contaminants related to the University of Utah's storage yard have not been released to soil on Fort Douglas. TPH concentrations were reported at 60 and 20 μg/g in the

surface soil sample and the 0.5 to 5.0 ft bgs sample from SB-30, respectively; no other TPH detections were reported. These levels are within those measured in other soils that are interpreted to be free of site-related contaminants. Di-N-butyl phthalate, reported in three samples from SB-30 and also in the method blank, likely is a laboratory artifact. Pyrene was detected at a concentration of 0.080 $\mu g/g$ in the 0.5 to 5.0 ft bgs sample. Because this sample was collected below the asphalt and no deeper samples contained pyrene, it may have been derived from the asphalt. Metals were detected near or within the range of concentrations detected in background soils. Therefore, migration pathways and contaminant degradation/persistence/mobility are not discussed for this area.

5.4 TRANSFORMERS

Results of the EI indicate that PCB 1260 is present at a concentration of 200 $\mu g/g$ in transformer oil from two transformers (samples 15-02 and 15-03). Potential leakage from the transformers was noted, as minor residue and oil stains were noted around the bushings. The extent of staining on the transformers was limited, and no stained soil was observed below these transformers (Section 3.3). No other transformers contained PCBs.

5.4.1 POTENTIAL CONTAMINANT MIGRATION PATHWAYS

Potential migration pathways of the PCBs from the transformers include leakage to the soil (with potential additional migration), direct contact (if the transformers are repaired, replaced, or additionally sampled), and volatilization.

5.4.2 CONTAMINANT DEGRADATION/PERSISTENCE/MOBILITY AND MIGRATION

PCBs are mixtures of chlorinated biphenyls. PCB 1260, also known as Aroclor 1260, is a PCB mixture containing biphenyls and 60 percent by weight chlorine. PCB 1260 has low solubility (0.0027 mg/L at 25 degrees C; Walton, 1985) and vapor pressure, and a high Kow. These characteristics indicate that the PCBs should not leach or volatilize and will adsorb to soil organic matter.

The most likely pathways of migration are direct contact by humans and leakage to the soil.

5.5 LEAD PAINT

Results for the paint chip samples indicate lead-based paint is present in all of the buildings on Fort Douglas, and lead also is contained in exterior paint. However, most of the buildings at Fort Douglas are constructed of brick or sandstone, and porches, eaves, and trim typically are the only painted exterior surfaces. Lead also was found to be present in the dust inside of all of the buildings sampled with wipes.

5.5.1 POTENTIAL CONTAMINANT MIGRATION PATHWAYS

In the building interiors potential migration pathways include the air, after the lead has been released from the painted surfaces; and abrasion of the paint, near windows, doors, on floors or other areas where the paint could be disturbed, and in areas that are cleaned. The lead dust may remain in the building interior or may migrate to other locations via the wind or house cleaning. Exterior lead-based paints may migrate to the soil, through deterioration induced by ultraviolet light, wind or precipitation, or by direct contact, during activities such as repairs or repainting. In addition, to keep exterior painted surfaces looking fresh, exterior paints formerly were designed to "chalk" or release some surface paint due to rain and ultraviolet light (Federal Register, 55:14561). Additional migration from the soil may occur via particulate transport, surface runoff, or infiltration and percolation.

5.5.2 CONTAMINANT DEGRADATION/PERSISTENCE/MOBILITY AND MIGRATION

Lead generally does not break down in the environment and has low solubility in water. Therefore, little change in the lead concentration of painted surfaces at Fort Douglas is expected.

The most likely migration pathway of lead is the air, through use of the buildings, by abrasion of the paint and subsequent dispersion in the building interiors. A minor pathway is release of lead from building exteriors to the soil, as paint chips were noted on the ground on the perimeter of a few of the buildings.

5.6 RADON

The long-term radon program indicated radon levels were above the USEPA recommended average long-term exposure limit of 4.0 pCi/L in four buildings. Retesting for structures with levels above 3.3 pCi/L

was recommended by the Army's QA contractor, Vail Research and Technology Corporation (VRT); however, Fort Carson decided to proceed by mitigating any structure with a level measuring 3.3 pCi/L or above during the long-term monitoring program (personal communication, Nelson Kelm, Fort Carson). Ten structures (including all family housing units within each structure) on the excessed area of Fort Douglas have been remediated, including 1(A&B), 10(A&B), 11(A&B), 12(A&B), 13(A&B), 14(A&B), 16(A&B), 18(A&B), 20 and 32. The work has been completed, and the mitigated structures are being retested for an additional year to determine if the remedial actions were effective in reducing the radon levels.

5.6.1 POTENTIAL MIGRATION PATHWAYS

Potential migration of radon from specific building interiors include migration to the atmosphere or to the air in adjacent housing units, through ductwork that may connect between units.

5.6.2 CONTAMINANT DEGRADATION/PERSISTENCE/MOBILITY AND MIGRATION

Radon is a naturally occurring radioactive gas which is present at some concentration in most, if not all, soils. Variables affecting indoor radon concentrations at a given location include: 1) the mineralogy of soils, sediments, and underlying bedrock, 2) the texture and permeability of earth materials underlying the site, 3) entry routes from the underlying soil into the structures such as foundation cracks and utility pipe penetrations, 4) ventilation routes within structures and/or crawlspaces. Radon moves from the soil into structures as a result of higher pressure in the soil pore space than in the structures. This movement is due primarily to temperature differences. Although radon concentrations in soil gas are relatively high, concentrations in the atmosphere never reach hazardous levels due to dilution and the short half-life of radon (3.8 days).

High concentrations of indoor radon have frequently been measured in structures located near the Wasatch Mountains, primarily due to the enhanced mobility of the gas in the abundant coarse-grained sediments and to the absence of shallow ground water, which would impede the migration of radon. Radon mitigation strategy commonly consists of one or more of the following actions: 1) seal migration routes from the soil into the structure, 2) increase the fresh air exchange rate by adding ventilation systems in the structure and/or crawlspace, and 3) reverse the pressure relationship between the soil and interior of the structure by inducing either negative pressure under the foundation slab or positive pressure in the

structure interior. At Fort Douglas, migration routes have been sealed and fresh air exchange has been increased by enhancement/addition of ventilation systems.

5.7 CONCEPTUAL SITE MODEL

The sources of contaminants, release mechanisms, and pathways of migration presented above can be summarized in a conceptual site model. Exposure routes to potential receptors and risk scenarios for sources of contamination can be identified from this model. Asbestos in Fort Douglas buildings is not presented in this site model, because, as discussed in Section 2.3.6, asbestos was assessed in the report of the Asbestos Survey Results (RLSA, 1991d), and Fort Carson conducted limited abatement in some of the buildings (Appendix C).

Figure 5-1 is the conceptual site model for Fort Douglas. The major pathway (soil) to receptor populations is shown by a bold line. Minor pathways are shown by a lighter line. Migration pathways from transformers and buildings containing radon to receptor populations are shown by a dashed line. These pathways are not addressed by the risk assessment for the following reasons:

- Buildings with elevated radon levels (as indicated by USEPA guidance) have been remediated by Fort Carson and will be retested; and

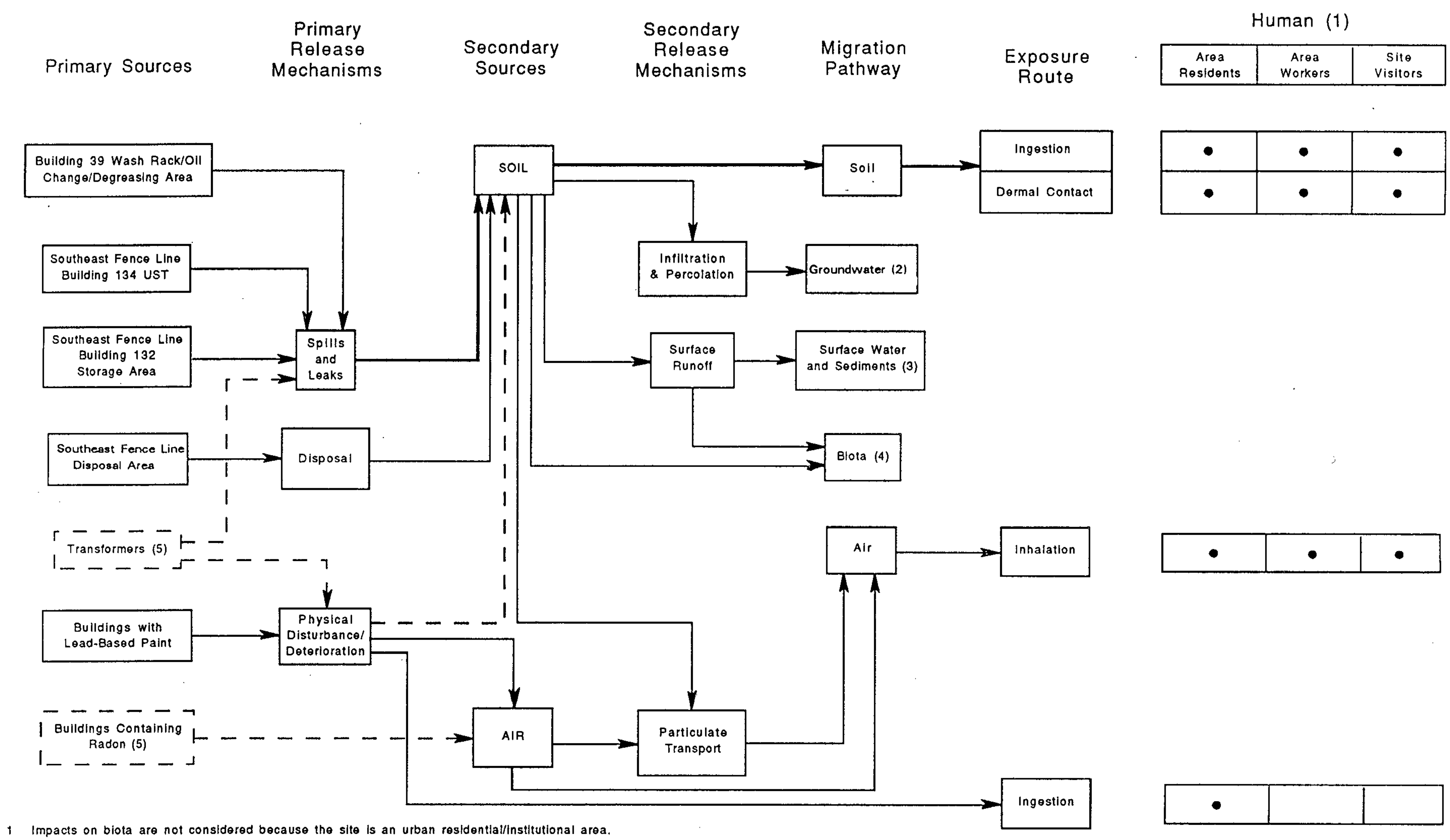
- It is inappropriate to conduct a risk assessment on the transformers, as they are not considered environmental media. Additionally, release of transformer oil to the soil was not observed; therefore, typical area residents, workers and visitors would not be exposed to the transformer oil.

The following factors were considered in developing the model (USEPA, 1987):

- spacial distribution of contaminants;

- potential routes of exposure;

- amount, concentrations, properties, environmental fate of chemicals at each source;



1 Impacts on biota are not considered because the site is an urban residential/institutional area.

2 Exposure routes relative to groundwater use are incomplete due to the use of city water and the depth of the aquifer.

3 No surface water bodies are on-site and potential exposure to off-site surface water and sediments in Red Butte Creek is considered minimal; therefore, no exposure routes are considered.

4 Human exposure to biota and agricultural products is incomplete because the site is an urban residential/institutional area and potential foods produced on-site are not expected to constitute a significant percentage of a resident's diet.

5 Exposure routes/risk are not assessed (see Section 5.7).

minor receptor route
major receptor route
receptor route not assessed

Note: Buildings containing asbestos are addressed in the report of the Asbestos Survey Results (RLSA, 1991b) and the Fort Carson Information paper (Appendix C)

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Figure 5-1
Conceptual Site Model

1333-001

- geologic and hydrogeologic factors;
- extent of contaminant migration in the environmental media;
- primary and secondary contaminant release mechanisms for each source; and
- human and environmental populations potentially affected.

The primary sources, based on the EI, are shown on the left side of Figure 5-1. The primary release mechanism is spills and leaks to soils; the soils may be secondary sources. As indicated on the right side of Figure 5-1, the primary pathway that may release contaminants is soil. Human receptors may be exposed by ingestion and dermal contact. Another potential migration pathway is air, where contaminated particulates could be entrained and inhaled by humans; however, the site is covered by sod or natural vegetation, and there is no vehicular traffic in these areas, reducing the potential of this pathway. Human exposure to biota and agricultural products are not major exposure pathways because the site is an urban residential/institutional area. Exposure through ingestion of contaminated foods is unlikely because the locations of the contaminated areas are not conducive to gardening. In addition, the ground-water, surface-water and sediment, and biota pathways are non-existent, incomplete, or of minor significance for the following reasons: 1) city water is used on site and the aquifer depth is approximately 350 ft bgs; 2) no surface-water bodies exist on site, and potential exposure to off-site surface water and sediments in Red Butte Creek is considered minimal because the creek is not used for human consumption and swimming is not permitted; and 3) the site is an urban residential/institutional area and has a vegetative landscape of lawns and trees and biota easily adapted to urban habitats. These are discussed in more detail in Section 6.2.2, Exposure Pathways.

6.0 RISK ASSESSMENT

This baseline risk assessment addresses the potential health risk associated with human exposure to contaminants detected at Fort Douglas. Potential health risks to ecological species are not evaluated in this assessment because impacts to ecological receptors are not anticipated at the site (Dames and Moore, 1991). As referenced in the Enhanced PA (Weston, 1989), the only known endangered species is the peregrine falcon that has been observed approximately 4 miles from Fort Douglas. There are no wildlife refugees or wetlands within 5 miles of the facility. The nearest sensitive environment is Red Butte Canyon, located less than a mile to the northeast.

This risk assessment evaluates the potential risk to both current and future human populations on the base. In the Northern Excessed Area, military personnel have lived in provided housing. In the future, the University of Utah may use the housing areas for residential housing. Future resident populations may include adults and children. Therefore, potential health risks to both adults and children are evaluated under a residential scenario in this risk assessment. The base is currently maintained by civil service personnel who access the base for employment activities only; therefore, the potential for occupational exposure also exists. This occupational scenario is assumed to continue in the future. The major difference between current and future use of the property is the use of the area by university students and faculty. The purpose of this risk assessment is to formally address the potential health risks which may be posed to these likely populations in the absence of any environmental remediation.

A *risk assessment* is a formal procedure, developed by the USEPA Office of Emergency and Remedial Response, to assess human health risk associated with potential exposures to contaminants in different types of media. An assessment of risk to human health involves three processes, 1) the exposure assessment, 2) the toxicity assessment, and 3) the risk characterization. An exposure assessment is an evaluation of the pathways by which humans may be exposed to contaminants, as well as an estimation of the magnitude, frequency and duration of their potential exposure. A toxicity assessment is an evaluation of the toxic properties of contaminants, including an identification of the adverse health effects which are associated with each contaminant, and a quantitation of the relationship between exposure (i.e., dose) and the occurrence of adverse effects. The risk characterization is a summary of the combined results of the exposure assessment and the toxicity assessment. In a risk characterization, quantitative estimates (i.e., numerical values) of risk are calculated which summarize baseline health risks. These quantitative estimates are qualified by a discussion of the uncertainties inherent in the risk estimates. The overall purpose of a risk assessment is to provide information for determining whether remedial action

should be taken on a site due to the extent of contamination. The specific objectives of this assessment are to:

- provide an analysis of baseline risks (risks present if no remediation is instituted) and assist in determining the need for clean-up action at the site;

- provide a basis for determining what level of contamination can remain on site and still be adequately protective of human health;

- provide a basis for comparing potential health impacts of various remedial alternatives; and

- provide a risk assessment process which is consistent with USEPA methods for evaluating and documenting public health threats at contaminated sites.

6.1 IDENTIFICATION OF CHEMICALS OF POTENTIAL CONCERN

The results of the sampling effort at Fort Douglas are evaluated in this section to identify chemicals of potential concern (COCs) at the site. USEPA defines "chemicals of potential concern" as those "that are potentially site-related and whose data are of sufficient quality for use in the quantitative risk assessment" (USEPA, 1989a). Therefore, the purpose of the following data evaluation step is to ensure that only those chemicals that are associated with past site activity, that are represented by quality data, and that present a potential health risk due to their toxicity, are carried through the risk assessment.

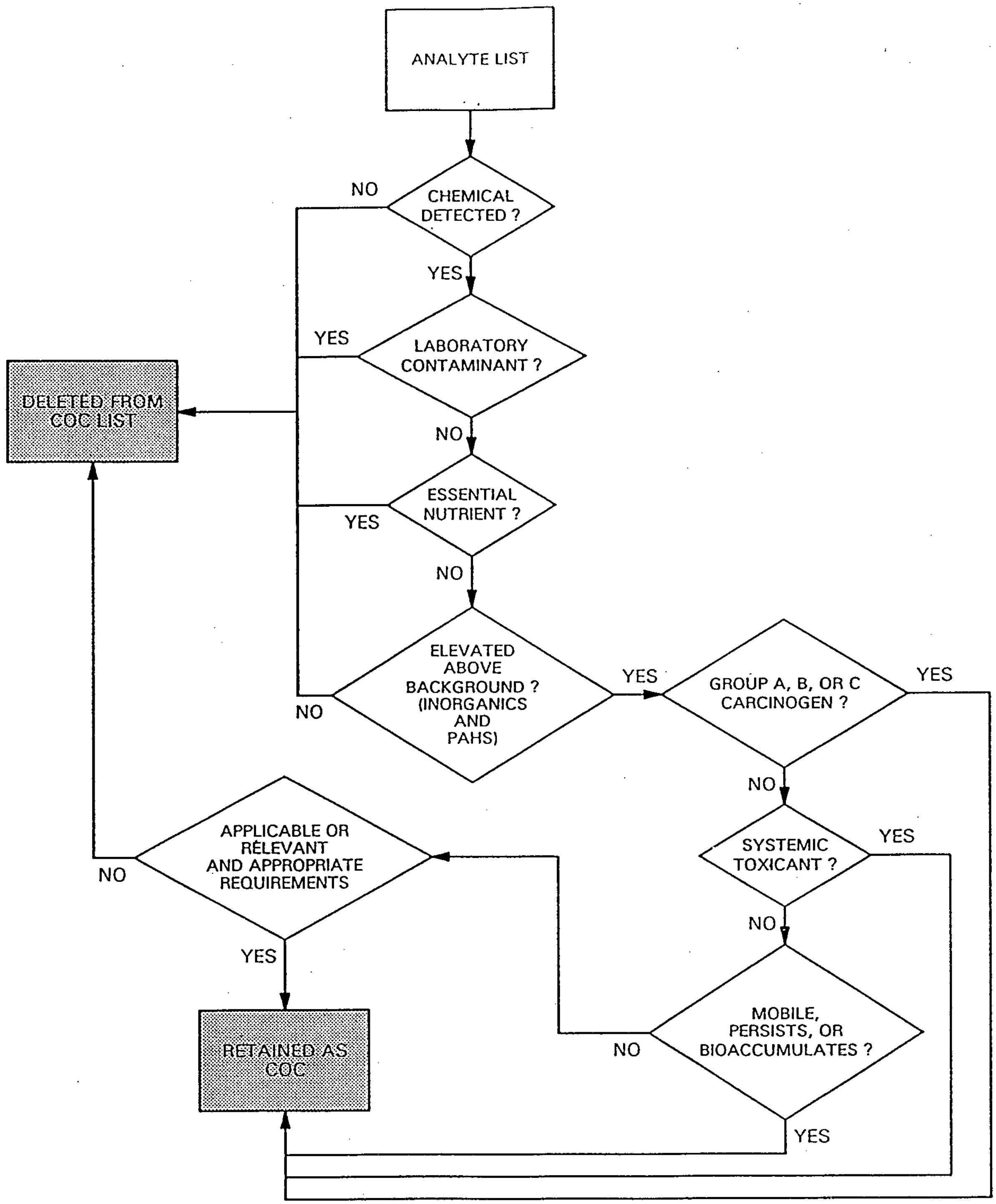
The chemical contaminants that have been detected in the surficial soil at Fort Douglas are identified in Table 6-1. These compounds, along with many other potential contaminants which have not been detected, were analyzed for in soil as part of a sampling plan that included an extensive list of target compounds (see Table 3-1). The list of target compounds is based on information about past activities at Fort Douglas which may have resulted in chemical impacts to the environment (see Sections 2 and 3). Since the sampling plan and the list of target analytes are based on historical activities, it is unlikely that chemical contaminants exist in Fort Douglas soil which are not identified in Table 6-1.

The contaminants listed in Table 6-1 are evaluated below by several criteria recommended by USEPA for defining COCs (USEPA, 1989a). These criteria are identified in Figure 6-1 and discussed in the following sections.

Table 6-1 Chemical Contaminants Found in the Surface Soil at Fort Douglas

ORGANIC CHEMICALS	INORGANIC CHEMICALS
Benzo(a)anthracene	Aluminum
Benzo(a)pyrene	Arsenic
Benzo(b)fluoranthene	Barium
Benzo(k)fluoranthene	Beryllium
Bis(2-ethylhexyl)phthalate	Cadmium
Fluoranthene	Calcium
Indeno[1,2,3(c,d)]pyrene	Chromium
Methylnaphthalene*	Cobalt
Naphthalene	Copper
Phenanthrene	Iron
Pyrene	Lead
Total Petroleum Hydrocarbons	Magnesium
	Manganese
	Mercury
	Nickel
	Potassium
	Silver
	Sodium
	Thallium
	Vanadium
	Zinc

* includes 1-methylnaphthalene and 2-methylnaphthalene



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SELECTION PROCESS FOR CHEMICALS OF POTENTIAL CONCERN (COCs)

FTD25014\DV1

Date: March 1994	Figure 6–1

6.1.1 POTENTIAL SITE-RELATED CONTAMINATION

Historical information and information gained from site visits indicate that constituents related to gasoline, oil (waste and fresh), organic solvents, and potentially heavy metals may be present in soils in the Building 39 Area and the Southeast Fence Line Area. In the Building 39 Area, TPH and PAHs were detected in soil, indicating that oil was released to the soil from the wash rack/oil change/degreasing area. Results of the GC/MS analyses indicate that heavy oil compounds are present in samples collected from the Building 39 and Southeast Fence Line Areas. In the Southeast Fence Line Area, oil (both waste and fresh) and possibly organic solvents historically were stored on the retained area. At the time of the field investigations, other materials, including containers of methanol, lube oil enamel, possibly gasoline and oil, and an automobile battery were located adjacent to the excessed area. Several man-made objects, including cast iron pipe, were contained in soil samples from the excessed area. Used vehicle oil filters were also noted in the excessed area. Contaminants detected in the soils that may have been released from these areas include TPH, PAHs, and heavy metals. Consequently, all soil contaminants which represent these three chemical classes or types of contamination are retained in this risk assessment because of their site relevance.

6.1.2 LABORATORY CONTAMINATION

One of the organic chemicals detected in Fort Douglas soils is considered by the USEPA to be a "common laboratory contaminant" (i.e., bis(2-ethylhexyl)phthalate). Common laboratory contaminants are those chemicals which can be readily introduced into a sample during routine laboratory analyses and, thus, are not site-related. These contaminants include such compounds as acetone, 2-butanone, methylene chloride, toluene, and the phthalate esters. According to the Functional Guidelines for Organics (USEPA, 1988a), if the analytical blank sample contains detectable levels of common laboratory contaminants, then the detection of these contaminants in source area samples should be considered positive only if the concentration in the source area sample exceeds ten times the amount detected in the blank.

Evaluation of the laboratory data indicates that the concentration of bis(2-ethylhexyl)phthalate detected in the field sample does not exceed 10 times the concentration detected in the method blank. However, bis(2-ethylhexyl)phthalate was detected in only one of 14 samples at 0.58 ppm (detection limit of 0.39 ppm), which corresponds to a detection frequency of 7 percent. If the one detection of 0.58 ppm is assumed to represent the exposure point concentration in soil for the entire site, a cancer risk estimate

of 1.3E-8 is calculated (based on a slope factor of 1.4E-2 kg-d/mg), and a hazard quotient of 0.0001 is calculated (based on an oral RfD of 2E-2 mg/kg-d) using the algorithm for soil ingestion from Section 6.2.4.1 of this report. These risk estimates indicate that the addition of the one detection of bis(2-ethylhexyl)phthalate to the risk assessment would not substantively change the characterization of site risk. Therefore, bis(2-ethylhexyl)phthalate is eliminated from this risk assessment.

Two inorganic chemicals, thallium and beryllium, were detected in both laboratory blanks and Fort Douglas soil samples. According to the Functional Guidelines for Inorganics (USEPA, 1988b), detections of inorganic chemicals in source area samples are considered positive only if the detected concentrations are five times greater than that detected in the blanks. Since thallium and beryllium concentrations in the laboratory blanks were greater than those detected in Fort Douglas soil samples, thallium and beryllium are not considered to be COCs in this assessment.

6.1.3 ESSENTIAL NUTRIENTS

Several of the inorganic chemicals detected in Fort Douglas soils are considered to be essential human nutrients: calcium, copper, iron, magnesium, potassium, sodium, and zinc. These chemicals were detected in both background and source area samples at similar concentrations (see Tables 4-4 to 4-8). Because these chemicals are essential human nutrients and toxic only at very high doses, they are not usually evaluated as part of a risk assessment (USEPA, 1989a). Accordingly, these chemicals are eliminated from further consideration in this assessment.

6.1.4 COMPARISON OF SAMPLE CONCENTRATIONS WITH BACKGROUND CONCENTRATIONS AND PROPOSED SOIL ACTION LEVELS

The USEPA recommends that the concentration of inorganic chemicals detected in source area samples be compared with naturally occurring levels (i.e., background concentrations). If the levels of inorganic chemicals in the source area samples are the same as naturally occurring levels, then the inorganic chemicals can be eliminated from the quantitative risk assessment (USEPA, 1989a). Likewise, PAHs can appear ubiquitously in the environment, due to both natural and anthropogenic processes (USEPA, 1989a). These compounds may also be eliminated from the risk assessment if source areas do not contain elevated levels of PAHs as compared to background areas (USEPA, 1989a).

The data presented in Table 6-2 and Table 6-3 show the concentrations of inorganic chemicals that were detected in Fort Douglas soils, excluding the essential nutrients and laboratory contaminants (thallium and beryllium). Geometric means, 95UCL values, and maximum detected concentrations for both background and potential source areas are shown. Comparison of the data reveals that both the 95UCL values and the maximum detected concentrations for source areas are less than or equal to the corresponding values for the background area for most of the inorganic chemicals. A few exceptions are noted. In the Building 39 Area, the 95UCL values for chromium, manganese, and mercury, and the maximum detected concentration for arsenic, barium, lead, manganese, mercury, and silver are slightly greater than the corresponding background values. In the Southeast Fence Line Area, the 95UCL values for arsenic, lead and mercury, and the maximum detected concentration for arsenic, barium, cadmium, chromium, lead, mercury, and silver are greater than the corresponding background values.

The data in Table 6-2 and Table 6-3 indicate that the concentration of some inorganic chemicals may be slightly elevated in the study areas as compared to the background area. However, because the number of samples in the background data set (e.g., 4 to 5) is not equal to the number of samples in the source area data sets (e.g., 6 to 16), statistical comparisons between background and source area data must be interpreted with caution. To supplement this analysis, however, the concentrations of inorganic chemicals in source area samples are compared to USEPA health-based Proposed Soil Action Levels (Federal Register, 55:30797). As the data in Table 6-4 indicate, the concentrations of inorganic chemicals in both source areas are well below the USEPA Proposed Soil Action Levels. Based on this analysis, none of the inorganic chemicals which have USEPA Proposed Soil Action Levels are considered to be COCs at Fort Douglas.

Health-based soil criteria for aluminum and cobalt have not been proposed by the USEPA, because the data for these compounds are either unavailable or inadequate for use in risk assessment. Because of this lack of data, neither aluminum nor cobalt are addressed further in this assessment.

An evaluation of lead as a COC at Fort Douglas is addressed in the following section.

Surface soil in both source areas contained PAHs (Tables 4-6 and 4-8). Except for one low detection of pyrene (e.g., 0.041 mg/kg), PAHs were not detected in any of the background soil samples (Table 4-4). The limit of detection was 0.033 mg/kg. Based upon this observation, all of the PAHs which were detected in source area samples are considered to be COCs.

Table 6-2 Comparison of Inorganic Chemical Concentrations in Background and Building 39 Source Area Soil Samples

CHEMICAL	BACKGROUND			BUILDING 39		
	GEOMETRIC MEAN	95UCL	MAXIMUM CONCEN-TRATION	GEOMETRIC MEAN	95UCL	MAXIMUM CONCEN-TRATION
Aluminum	10,000	17,000	21,000	14,000	16,000	16,000
Arsenic	5.05	5.83	6.12	5.02	5.80	6.32
Barium	120	150	146	120	150	170
Cadmium	0.967	2.03	1.93	1.16	1.34	1.39
Chromium	26	43	48.1	40	52	37.0
Cobalt	14.8	23.5	22.3	17.9	21.3	21.0
Lead	31	91	82	40	58	83
Manganese	500	650	702	660	840	910
Mercury	0.018	0.037	0.052	0.026	0.048	0.062
Nickel	17.5	27.4	25.4	21.4	25.2	24.9
Silver	0.681	1.99	1.26	1.33	1.75	1.72
Vanadium	20.7	35.4	33.6	24.0	27.2	26.8

95UCL= 95th percent upper confidence limit.

Notes: All concentrations are in $\mu g/g$.

Mean values are based on actual detections (rounded values) and one-half the detection limit when no detection was reported.

Table 6-3 Comparison of Inorganic Chemical Concentrations in Background and Southeast Fence Line Source Area Soil Samples

CHEMICAL	BACKGROUND			SOUTHEAST FENCE LINE		
	GEOMETRIC MEAN	95UCL	MAXIMUM CONCEN-TRATION	GEOMETRIC MEAN	95UCL	MAXIMUM CONCEN-TRATION
Aluminum	10,000	17,000	21,000	9,600	11,000	15,000
Arsenic	5.05	5.83	6.12	5.32	6.33	11.6
Barium	120	150	146	130	150	199
Cadmium	0.967	2.03	1.93	1.11	1.55	2.21
Chromium	26	43	48.1	29	38	150
Cobalt	14.8	23.5	22.3	14.4	16.1	18.8
Lead	31	91	82	89	140	320
Manganese	500	650	702	460	540	656
Mercury	0.018	0.037	0.052	0.070	0.12	0.285
Nickel	17.5	27.4	25.4	16.6	18.0	20.9
Silver	0.681	1.99	1.26	0.987	1.72	14
Vanadium	20.7	35.4	33.6	18.9	21.7	25.5

95UCL= 95th percent upper confidence limit.

Notes: All concentrations are in $\mu g/g$.

Mean values are based on actual detections (rounded values) and one-half the detection limit when no detection was reported.

Table 6-4 Comparison of Inorganic Chemical Concentrations in Source Area Soils with USEPA Proposed Soil Action Levels

CHEMICAL	USEPA PROPOSED ACTION LEVELS[a]	BUILDING 39 MAXIMUM DETECTION	SOUTHEAST FENCE LINE AREA MAXIMUM DETECTION
Aluminum	NA	16,000	15,000
Arsenic	80	6.32	11.6
Barium	4,000	170	199
Cadmium	40	1.39	2.21
Chromium	400[b]	37.0	150
Cobalt	NA	21.0	18.8
Lead	NA	83	320
Manganese	8000[c]	910	656
Mercury	20	0.062	0.285
Nickel	2,000	24.9	20.9
Silver	200	1.72	14
Vanadium	700	26.8	25.5

Note: All concentrations are in $\mu g/g$.
NA = not available
a = Taken from Federal Register Vol. 55, No. 145, 30797-30833, 1990.
b = This Action Level is for chromium VI, whereas the concentrations of chromium in the two source areas represent total chromium.
c = This value has been calculated for the purposes of this assessment using the same USEPA methodology cited in footnote "a" above.

6.1.5 Applicable or Relevant and Appropriate Requirements

Analytical results indicate that TPH is present in some of the source area soil samples. However, no quantitative data are provided for specific chemical constituents of the TPH, since the analyses tested only for the presence of TPH and not for the individual chemical constituents thereof (see Table 6-5). The GC/MS analyses do indicate, however, that the chemical constituents are most likely PAHs and that light hydrocarbons such as benzene, toluene, ethylbenzene and xylenes (i.e., BTEX) are not present. The TPH data shown in Table 6-5 cannot be addressed quantitatively in this risk assessment because the data are not compound-specific (i.e., specific chemical constituents of the TPH were not identified). Since PAHs are common constituents of TPH, and the USEPA has classified PAHs as probable human carcinogens, all PAHs detected in soil are retained and evaluated as COCs. Besides PAHs and BTEX, the remainder of the hydrocarbons detected by the TPH analysis are not known to be of concern to human health or the environment, so further evaluation of these hydrocarbons is not performed in this assessment.

As discussed in Section 4.8.1, lead was detected in the paint chip and wipe samples that were collected from inside the on-site structures. The data are shown in Table 4-11. On a percent-by-weight basis, the amount of lead detected in the paint chip samples ranged from 0.002 percent to 40 percent. In some of the structures, including residential units, the amount of lead exceeds what the Department of Housing and Urban Development (HUD) currently defines as a lead-based paint hazard (e.g., 0.5 percent by weight) for public housing units (Federal Register, 55:14562). If the HUD criterion for lead-based paint of 0.5 percent by weight is used as a potential ARAR for comparison, then the data shown in Table 4-11 suggest that the lead content in some of the Fort Douglas buildings may be above what is considered safe for young children. Because of this possibility, lead is considered to be a COC at Fort Douglas. The health risks associated with exposure to lead will be addressed qualitatively in this risk assessment.

6.1.6 Mobility, Persistence, and Bioaccumulation

None of the COCs are eliminated from this risk assessment on the basis of their lack of mobility, persistence, or bioaccumulation.

Based on the above set of criteria, the chemical contaminants at Fort Douglas which are considered to be COCs are listed in Tables 6-6 and 6-7 for the Building 39 Area and the Southeast Fence Line Area, respectively.

Table 6-5 Summary of TPH Analyses (Page 1 of 2)

SITE ID	DEPTH INTERVAL (ft)	CONCENTRATION ($\mu g/g$)	SAMPLE LOCATION
SS-01	0-0.5	10	Southeast Fence Line Area
SB-24	0-0.5	30	
	0.5-1.0	20	
SB-25	0-0.5	600	
	0.5-4.0	20	
SB-26	0-0.5	6,000	
	0.5-3.4	1,000	
SB-27	0-0.5	900	
	0.5-3.0	700	
SS-09	0.0-0.5	400	
SS-10	0.0-0.5	70	
SS-11	0.0-0.5	200	
SS-12	0.0-0.5	2,000	
SS-13	0.0-0.5	60	
SS-14	0.0-0.5	30	
SS-15	0.0-0.5	50	
SS-16	0.0-0.5	20	
SS-17	0.0-0.5	90	
SS-18	0.0-0.5	30	
SS-19	0.0-0.5	<10	
SS-20	0.0-0.5	90	
SS-21	0.0-0.5	10	
SS-22	0.0-0.5	200	

Table 6-5 Summary of TPH Analyses (Page 2 of 2)

SITE ID	DEPTH INTERVAL (ft)	CONCENTRATION (μg/g)	SAMPLE LOCATION
SB-28	0.0-0.5	40	Building 39 Area
	0.5-5.0	<10	
SB-29	9.7-9.9	70	
	14.0-18.7	100, <10	
	9.0-21.1	10	
	24.0-26.6	60	
SB-31	0.0-0.5	20	
	0.5-3.2	500	
SS-03	0.0-0.5	<10	
SS-04	0.0-0.5	<10	
SS-05	0.0-0.5	<10	
SS-06	0.0-0.5	<10	
SS-07	0.0-0.5	30	
SS-08	0.0-0.5	50	
SS-02	0-0.5	60	Storage Yard
SB-30	0.5-5.0	20	
	5.0-9.5	<10	
	15.0-20.0	<10	
	25.0-25.8	<10	

Note: TPH concentrations in background soil samples ranged from <10 to 90 μg/g.

Table 6-6 Chemicals of Potential Concern and Their Corresponding Exposure Point Concentrations in the Building 39 Area Soil

CHEMICAL	Arithmetic Mean	Maximum Detected Concentration	95UCL	Exposure Point Concentration[1]
Benzo(a)anthracene	0.022	0.055	0.039	0.039
Benzo(a)pyrene	0.026	0.076	0.052	0.052
Benzo(b)fluoranthene	0.024	0.067	0.046	0.046
Benzo(k)fluoranthene	0.032	0.11	0.072	0.072
Phenanthrene	0.022	0.051	0.037	0.037
Pyrene	0.038	0.12	0.081	0.081
Total Petroleum Hydrocarbons	20	50	40	40
Lead	44	83	60	60

Note: All concentrations are in $\mu g/g$.

[1] - The derivation and use of exposure point concentrations are discussed in Section 6.2.3.

Table 6-7 Chemicals of Potential Concern and Their Corresponding Exposure Point Concentrations in the Southeast Fence Line Area Soil

CHEMICAL	Arithmetic Mean	Maximum Detected Concentration	95UCL	Exposure Point Concentration[1]
Benzo(a)anthracene	0.045	0.16	0.072	0.072
Benzo(a)pyrene	0.044	0.14	0.068	0.068
Benzo(b)fluoranthene	0.051	0.19	0.086	0.086
Benzo(k)fluoranthene	0.038	0.11	0.058	0.058
Fluoranthene	0.085	0.37	0.14	0.14
Indeno[1,2,3(c,d)]pyrene	0.025	0.10	0.040	0.040
Methylnaphthalene[2]	0.064	0.16	0.094	0.094
Naphthalene	0.049	0.12	0.070	0.070
Phenanthrene	0.048	0.17	0.073	0.073
Pyrene	0.070	0.30	0.12	0.12
Total Petroleum Hydrocarbons	700	6,000	1,000	1,000
Lead	120	320	180	180

Note: All concentrations are in μg/g.

1 - The derivation and use of exposure point concentrations are discussed in Section 6.2.3.

2 - Includes 1-methylnaphthalene and 2-methylnaphthalene.

6.2 EXPOSURE ASSESSMENT

This section evaluates several pathways by which human receptors may be exposed to contamination at the Fort Douglas site. Several exposure scenarios are developed which address both current and future land use. In addition, the magnitude, frequency, and duration of exposure are quantified for all reasonable land use scenarios to estimate an average daily dose for all of the applicable human receptor populations.

6.2.1 REASONABLE LAND USE SCENARIOS

The contamination associated with Fort Douglas could potentially impact several existing and future human receptor populations. These populations include, 1) current and future workers who may be employed at the site, 2) current and future residents who may live on site (including both adults and children), 3) future students who may live in on-site university housing, and 4) future visitors. Given these potential human receptor populations, the following land use scenarios are considered reasonable and are addressed quantitatively in this risk assessment:

- On-site residential,
- On-site industrial, and
- On-site recreational.

6.2.2 EXPOSURE PATHWAYS

An exposure pathway describes the course which a chemical or physical agent may take from its source of contamination to the exposed individual. An analysis of an exposure pathway involves two processes, 1) an evaluation of the sources, locations, and types of environmental releases, and 2) an assessment of the location of any human receptor populations and their activity patterns. The objective of an exposure pathway analysis is to determine the significant pathways of human exposure. An exposure pathway includes the following four elements:

- a source and mechanism of release,

- a retention, transport, or release medium (e.g., air, soil, or water),
- a human exposure point, and
- an exposure route (e.g., ingestion, inhalation, absorption) at the point of contact.

In order for an exposure pathway to be complete, all four of the above elements must be present. For the Fort Douglas site, the following exposure pathways are considered to be complete and important because of either current or future land use scenarios.

RESIDENTIAL SCENARIO (CURRENT & FUTURE)

Ingestion of soil: The potential exists for children and adults to ingest contaminated soil incidentally.

Dermal contact with soil: The potential exists for children and adults to absorb contaminants through the skin as a result of skin contact while gardening (adults) and while playing outdoors (children).

INDUSTRIAL SCENARIO (CURRENT & FUTURE)

Ingestion of soil: The potential exists for workers to ingest soil incidentally as a result of accumulation on their hands, skin, lower arms, food, or cigarettes while they are engaging in activities such as grounds-keeping, trenching and excavating.

Dermal contact with soil: The potential exists for workers to absorb contaminants through the skin as a result of skin contact with contaminated soil.

RECREATIONAL SCENARIO (CURRENT & FUTURE)

Ingestion of soil: The potential exists for adults and children to ingest contaminated soil as a result of accumulation on their hands, skin, arms, or food while recreating on the site.

Dermal contact with soil: The potential exists for adults and children to absorb contaminants through the skin as a result of skin contact with contaminated soil.

In addition to the exposure pathways discussed above, several other potential exposure pathways are evaluated in this risk assessment for their applicability to the Fort Douglas site. These exposure pathways are listed below:

- Ingestion of chemicals from drinking ground water,
- Inhalation of chemicals in air,
- Ingestion of chemicals in surface water while swimming,
- Dermal contact with chemicals in water,
- Ingestion of contaminated fish,
- Ingestion of contaminated fruits and vegetables, and
- Ingestion of contaminated meat, eggs and dairy products.

None of the above, additional exposure pathways are incorporated quantitatively into this risk assessment. The rationale for their exclusion is based on the fact that these exposure pathways are either nonexistent, incomplete, or of minor significance relative to direct exposure to soil at the Fort Douglas site. For instance, the ingestion of chemicals from drinking groundwater is a nonexistent pathway because ground water in the immediate vicinity of the site is not used for domestic purposes; municipal water is supplied to the site from the Salt Lake City system. Furthermore, migration of contaminants to the regional aquifer and to downgradient locations is not likely; concentrations in soil were low and the depth of the regional aquifer is approximately 350 ft bgs.

Inhalation of site-related contaminants in air is not a significant exposure pathway at the site. VOCs were not detectable in soil, so exposure to volatile emissions is not of concern. Exposure to particulate emissions, such as PAHs adhering to fugitive dust, is a possibility at the site. However, the Building 39 Area is totally covered with sod, and the Southeast Fence Line Area is covered with natural vegetation. These conditions are not supportive of marked particulate emissions. According to USEPA guidance (USEPA, 1988c), the inhalation of fugitive dust is a potentially significant exposure pathway for sites

which have appreciable surficial soil contamination, evidence of wind-eroded areas, and vehicular traffic along contaminated, unpaved roads. None of these conditions exist now, or are likely to exist in the future at Fort Douglas. Because the Building 39 Area is included in the National Historic Landmark (Dames and Moore, 1991), and the Southeast Fence Line Area is relatively inaccessible, it is unlikely that changes will be made to their existing characteristics that would support marked particulate emissions.

Within the study area, exposure pathways related to the use of surface water, including swimming and ingestion of contaminated fish, are nonexistent because surface-water bodies do not exist on Fort Douglas. The only body of water near Fort Douglas is Red Butte Creek, which is located less than 500 feet beyond the Southeast Fence Line Area. The possibility exists that site-related contamination has reached the creek via surface-water runoff from the post. However, given the limited amount of on-site contamination, it is unlikely that a significant amount of contamination has impacted the creek. As an exposure point, Red Butte Creek presents minimal potential for impacting human health even if low levels of contamination are present. The creek is not used as a source of water for human consumption. Furthermore, because of its small size, the creek does not support swimming or a large enough fish population to create a chronic exposure scenario for humans.

Approximately 2 miles southeast of Fort Douglas lies Liberty Park Lake, into which Red Butte Creek flows. It is possible that potential contamination entering Red Butte Creek has been transported to the lake. However, Liberty Park Lake is not used as a potable water supply, and both swimming and fishing are prohibited in the lake. An assessment of Liberty Park Lake and/or surrounding ground water is beyond the scope of this study and would give little, if any, indication as to Fort Douglas' contribution to the water quality of the lake or quality of the ground water.

The exposure pathway involving ingestion of contaminated fruits and vegetables is a possibility at the site, given the presence of contaminants in soil, the propensity of plants to accumulate contaminants from soil, and the tendency of residential households to participate in some level of outdoor gardening in the summer. However, the contaminated areas at Fort Douglas are unlikely to be used for gardening because of their inaccessibility, topography, and distance from the housing units. The Southeast Fence Line Area is a sloped and narrow strip of land which is naturally vegetated; it is bordered by Red Butte Creek on one side and retained Army property on the other. These characteristics make the Southeast Fence Line Area an improbable site for residential gardening. The Building 39 Area is a sodded, common area used for picnicking and as a playground; it is not likely to be used for residential gardening. A similar

rationale applies to the ingestion of contaminated meat, eggs, and dairy products. While chemical contaminants which are lipophilic in nature, such as PAHs, can sequester into meat, eggs, and dairy products, it is highly unlikely that this pathway will exist on the Fort Douglas site. The current zoning at the site does not support agricultural land use; and, it is unlikely that future zoning will permit such agricultural practices as animal husbandry on Fort Douglas, because of its location within a major metropolitan area.

The exposure parameters which are used in this risk assessment to quantitate the exposure pathways discussed above are summarized in Table 6-8.

6.2.3 EXPOSURE POINT CONCENTRATIONS

The concentrations of COCs in Fort Douglas surficial soils which are used to estimate exposure (i.e., to calculate an average daily dose) are shown in Tables 6-6 and 6-7 for the two study areas. For every COC, an arithmetic mean and a 95UCL on the arithmetic mean are calculated from surficial soil data only (i.e., 0 to 6 inches below ground surface or below the root zone in areas that were sodded). Thus, the exposure point concentrations are representative of soil conditions to which human receptors are actually exposed. To be conservative and protective, the 95UCL on the arithmetic mean, rather than the geometric mean, is used in this risk assessment to represent the concentration of COCs in Fort Douglas soils. This procedure, while statistically questionable, is meant to be health-protective and is consistent with USEPA guidance (USEPA, 1989a). As indicated in Tables 6-6 and 6-7, the exposure point concentrations are equivalent to the 95UCL of the arithmetic mean as recommended by USEPA guidance (USEPA, 1989a).

6.2.4 EXPOSURE EQUATIONS

The equations which are used to calculate average daily doses in this risk assessment are presented below. All of the exposure parameters used in these equations are defined below, and the numerical values of the parameters are provided below and are also summarized in Table 6-8. All exposure parameter values are taken from USEPA (1989a or 1991a) unless otherwise noted.

Table 6-8 Parameters Used to Estimate Exposure

PATHWAY	EXPOSURE PARAMETERS					
	Daily Intake Rate	Exposure Frequency (days/yr)	Exposure Duration (yrs)	Body Weight (kg)	Averaging Time [yr X (d/yr)]	Other Factors
Ingestion of soil (adult resident)	100 mg/day	350	24[1]	70	C[2] - 25,550 N[3] - 8,760	a b
Ingestion of soil (workers)	50 mg/day	250	25	70	C - 25,550 N - 9,125	a b
Ingestion of soil while playing (child resident)	200 mg/day	350	6	15	C - 25,550 N - 2,190	a b
Dermal contact with soil while gardening (adult resident)	NA	43[4]	24	70	C - 25,550 N - 8,760	a,e c,d
Dermal contact with soil during outdoor activities (workers)	NA	250	25	70	C - 25,550 N - 9,125	a,e c,d
Dermal contact with soil while playing (child resident)	NA	350	6	15	C - 25,550 N - 2,190	a,e c,d
Ingestion of soil during recreational activities (adults)	100 mg/day	52	24	70	C - 25,550 N - 8,760	a b
Ingestion of soil during recreational activities (children)	200 mg/day	52	6	15	C - 25,550 N - 2,190	a b
Dermal contact during recreational activities (adults)	NA	52	24	70	C - 25,550 N - 8,760	a, e c, d
Dermal contact during recreational activities (children)	NA	52	6	15	C - 25,550 N - 2,190	a, e c, d

NA = not applicable
a Fraction ingested (FI) = 1
b Conversion Factor (CF) = 10^{-6} kg/mg
c Skin surface area available for contact (SA) = 3120 cm^2/event for adults and workers[5], 3160 cm^2/event for children[6]
d Soil-to-skin adherence factor (AF) = 1.45 mg/cm^2
e Dermal absorption factor (ABS) = 0.03 for PAHs based on studies by Kao et al., 1985 and Wester et al., 1990.

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1 The exposure duration for an on-site resident is 30 years, and the average daily dose for the 30-year resident is calculated as a time-weighted average of a 24-year adult exposure and a 6-year child exposure.
2 C = Carcinogenic
3 N = Noncarcinogen
4 USEPA. Exposure Factors Handbook; EPA/600/8-89/043. (1989c). pp 2-52 (Based on summer exposure estimate for gardening).
5 Based on surface area of arms and hands
6 Based on surface area of arms, hands, and legs

6.2.4.1 Direct Ingestion of Soil

$$\text{Average Daily Dose (mg/kg-day)} = \frac{CS * IR * CF * FI * EF * ED}{BW * AT}$$

Where:

CS = Chemical concentration in soil (mg/kg)
IR = Ingestion rate (mg soil/day)
CF = Conversion factor (10^{-6} kg/mg)
FI = Fraction ingested from contaminated source (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

The numerical values of the above exposure parameters are as follows:

CS = see Tables 6-6 and 6-7 for exposure point concentrations
IR = 200 mg/day - children, ages 1 through 6
100 mg/day - adults, ages 7 through 30
50 mg/day - workers
CF = 10^{-6} kg/mg
FI = 1.0
EF = 350 days/year for residents, 250 days/year for workers, 52 days/year for recreators
ED = 30 years for residents and recreators (6 years as a child, 24 years as an adult), 25 years for workers
BW = 70 kg adult, 15 kg child
AT = Carcinogens: 365 days/year × 70 years
Noncarcinogens: 365 days/year × 30 years (residential and recreational)
365 days/year × 25 years (industrial)

For the residential and recreational scenarios, the average daily dose is calculated as a time-weighted average of childhood and adult exposures, as illustrated below for carcinogenic effects:

$$\text{Average daily dose} = \frac{1\ \text{mg/kg} \times 1.0 \times 1 \times 10^{-6}\ \text{kg/mg} \times 350\ \text{d/yr} \times \left[\left(\frac{200\ \text{mg/d} \times 6\ \text{yr}}{15\ \text{kg}}\right) + \left(\frac{100\ \text{mg/d} \times 24\ \text{yr}}{70\ \text{kg}}\right)\right]}{70\ \text{yr} \times 365\ \text{d/yr}}$$

$$= 1.6 \times 10^{-6}\ \text{mg/kg-d}$$

The results of the exposure assessment for the soil ingestion pathway are summarized for the residential, industrial, and recreational scenarios in Tables H-1 through H-6 of Appendix H.

6.2.4.2 Dermal Contact with Chemicals in Soil

$$\text{Average Daily Dose (mg/kg-day)} = \frac{CS * CF * SA * AF * ABS * EF * ED}{BW * AT}$$

Where:

CS = Chemical concentration in soil (mg/kg)
CF = Conversion factor (10^{-6} kg/mg)
SA = Skin surface area available for contact (cm^2/event)
AF = Soil-to-skin adherence factor (mg/cm^2)
ABS = Dermal absorption factor (unitless)
EF = Exposure frequency (days/year)
ED = Exposure duration (years)
BW = Body weight (kg)
AT = Averaging time (period over which exposure is averaged - days)

The numerical values of the above exposure parameters are as follows:

CS = see Tables 6-6 and 6-7 for exposure point concentrations
CF = 10^{-6} kg/mg
SA = 3160 cm^2 for children - arms, hands, and legs; 3120 cm^2 for workers and adults - forearms and hands (USEPA, 1989c)
AF = 1.45 mg/cm^2
ABS = 0.03 (Kao et al., 1985 and Wester et al., 1990)
EF = 350 days/year for child resident, 43 days/year for adult resident, 250 days/year for workers, 52 days/year for adult and child recreators
ED = 30 years for residents and recreators (6 years as a child, 24 years as an adult), 25 years for workers
BW = 70 kg adult, 15 kg child
AT = Carcinogens: 365 days/year × 70 years
Noncarcinogens: 365 days/year × 30 years (residential and recreational)
365 days/year × 25 years (industrial)

The results of the exposure assessment for the dermal contact pathway are summarized for the residential, industrial, and recreational scenarios in Tables H-7 through H-12 of Appendix H. As with the ingestion of soil pathway, the average daily dose for the dermal contact pathway is calculated as a time-weighted average of childhood and adult exposures, for both the residential and recreational scenarios.

6.3 TOXICITY ASSESSMENT

The purpose of the toxicity assessment is two-fold, 1) to evaluate the available data regarding a chemical's ability to cause an adverse health effect in exposed individuals, and 2) to estimate the relationship between the extent of exposure (or dose) and the magnitude of the resulting adverse response

(if any). The information which a toxicity assessment provides includes the toxicity values for each COC, if the toxicity values are available. Toxicity values are defined by the USEPA (1989a) as "numerical expressions of a substance's dose-response relationship." Toxicity values for noncarcinogenic effects are termed "references doses" (RfDs) and those for carcinogenic effects are termed "slope factors" (SFs).

RfDs and SFs are derived from scientific data, gathered by the USEPA from a variety of sources, which quantitate the potential for a substance to cause an adverse health effect. Sources of data may include experimental animal studies, clinical studies, and controlled epidemiologic investigations. Human studies, although seldom available, are accepted as the most convincing evidence about human risk. Human exposure data often come from the occupational setting or from accidental exposures; however, with these data, the dose and the duration of exposure are often not known. Thus, quantification of a human dose-response relationship is nearly impossible so evaluation of human data are often qualitative in nature. In addition, the latency periods between exposure and effect in humans may be highly variable and, therefore, not easily tracked. Other factors, such as diet, occupational and home environment, age, health, and activity patterns cannot be held constant within the human population. Often, these factors play a key role in an individual's epidemiologic response to an exposure.

Human studies (confirmed for validity and applicability) are given first priority in a dose-response assessment. When human data are unavailable, animal studies are used to estimate the potential for a substance to cause an adverse effect in humans. The validity of animal data increases as similar results are observed across strains, species, sexes, etc. Other studies (e.g., metabolic, pharmacokinetic, structure-activity) are considered by the USEPA in order to provide supportive data.

SFs are used to estimate the incremental lifetime risk of developing cancer. They are used to evaluate risks by multiplying chronic daily intakes (CDI) (calculated from the exposure assessment) by the SFs. Calculated risks are then compared to acceptable risk levels.

Noncarcinogenic health effects are typically evaluated by comparing estimated average daily intakes with RfDs. RfDs represent average daily intake levels at which no adverse health effects are expected to occur over a specified duration of exposure.

SFs and RfDs are route-specific. Inhalation and ingestion data are often available; however, dermal absorption data are not. Therefore, to estimate a dermal toxicity value from an oral route value, the oral toxicity value must be adjusted for the fraction absorbed gastrointestinally.

The primary source available for toxicity values is the Integrated Risk Information System (IRIS). IRIS is a USEPA computerized database which contains verified toxicity values, current health risk, and USEPA regulatory information for many hazardous chemicals. In addition, the Health Effects Assessment Summary Tables (HEAST; USEPA, 1991b) include toxicity information and values for chemicals for which Health Effects Assessments, Health and Environmental Effects Documents, Health and Environmental Effects Profiles, Health Assessment Documents, or Ambient Air Quality Criteria have been prepared.

Summaries of the toxicity data for the COCs at the Fort Douglas site are presented in Tables 6-9 and 6-10.

This toxicity assessment section addresses the chemical characteristics, uses, and basic toxicological properties of 11 of the 12 COCs found within the soil at Fort Douglas. These chemicals are: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)fluoranthene, fluoranthene, indeno[1,2,3(C,D)]pyrene, methylnaphthalene, naphthalene, phenanthrene, pyrene, and lead. The toxicological profile of TPH *per se* is not discussed because this COC is a complex mixture of substances and toxicity values are not available.

A brief description of each chemical is provided, followed by a discussion of the potential toxic effects associated with chronic exposure to each of the individual chemicals. Information regarding the toxicity of the chemicals has been summarized from documents and databases developed by the USEPA and the Agency for Toxic Substances and Disease Registry (ATSDR).

6.3.1 LEAD (INORGANIC)

Lead is ubiquitous in the environment, originating mostly from anthropogenic sources. Humans are usually exposed to lead by inhalation or ingestion, with occupationally exposed persons receiving a greater proportion through inhalation, and the general population receiving a greater proportion through

Table 6-9 Summary of Noncarcinogenic Toxicological Properties of COCs

Chemical	USEPA RfDs (mg/kg-day)	Critical Effect	Uncertainty Factor	Source
Benzo(a)anthracene	Not available			No IRIS No HEAST
Benzo(a)pyrene	Not available			No IRIS No HEAST
Benzo(b)fluoranthene	Not available			No IRIS No HEAST
Benzo(k)fluoranthene	Not available			No IRIS No HEAST
Fluoranthene				
Subchronic	Oral: 4E-1	Nephropathy, liver weight changes, hematological changes	300	HEAST
Chronic	Oral: 4E-2	Nephropathy, liver weight changes, hematological changes	3000	IRIS
Indeno[1,2,3(C,D)] pyrene	Not available			No IRIS No HEAST
Methylnaphthalene	Not available			No IRIS No HEAST
Naphthalene				
Subchronic	Oral: 4E-2	Decreased body weight gain	1000	HEAST
Chronic	Oral: 4E-3 (under review)	Decreased body weight gain	10,000	HEAST
Phenanthrene	Not available			No IRIS No HEAST
Pyrene				
Subchronic	Oral: 3E-1	Kidney effects	300	IRIS
Chronic	Oral: 3E-2	Kidney effects	3000	HEAST
Lead	Not determined	Neurological impairment		IRIS
TPH	Not available			No IRIS No HEAST

Table 6-10 Summary of Carcinogenic Toxicological Properties of COCs

Chemical	USEPA Slope Factors $(mg/kg\text{-}day)^{-1}$	Classification	Type of Cancer	Source
Benzo(a)anthracene	Oral: 1.1	B_2	Pulmonary hepatoma (mice)	USEPA
Benzo(a)pyrene	Oral: 7.3 Inhal: 6.1	B_2	Localized tumors at site of entry (mice)	IRIS HEAST
Benzo(b)fluoranthene	Oral: 1.0	B_2	Lung, thorax tumors (mice)	USEPA
Benzo(k)fluoranthene	Oral: 0.51	B_2	Lung, thorax tumors (mice)	USEPA
Fluoranthene	Not applicable	D	Not applicable	USEPA
Indeno[1,2,3(C,D)] pyrene	Oral: 1.5	B_2	Epidermoid carcinomas, injection site sarcomas, tumors (mice)	USEPA
Methylnaphthalene	Not available			No IRIS No HEAST
Naphthalene	Not applicable	D	Not applicable	IRIS
Phenanthrene	Not available			No IRIS No HEAST
Pyrene	Oral: 0.58	D	Not applicable	USEPA
Lead	Not determined	B_2	Renal tumors	IRIS
TPH	Not available			No IRIS No HEAST

ingestion of food, drinking water, dirt, and dust. Children are particularly sensitive to lead toxicity. Lead causes the same toxic effects regardless of the route of exposure (ATSDR, 1991).

Adverse health effects resulting from chronic exposure to high levels of lead have been observed in occupationally-exposed populations and children. Blood-lead levels in excess of 30 to 40 micrograms per deciliter (μg/dL) are associated with encephalopathy, gastrointestinal effects (colic), anemia, nephropathy, and abnormalities on electrocardiograms. Furthermore, high exposure to lead may cause spontaneous abortion in women and decreased fertility in men. Lower exposure levels in humans (i.e., blood-lead concentrations $<$30 to 40 μg/dL) have been shown to cause the following effects: abnormalities in heme synthesis, thereby affecting metabolic and energy-transfer processes; a decrease in circulating levels of the active form of vitamin D, which is responsible for maintenance of calcium homeostasis in the body; neurobehavioral effects and growth retardation in prenatally-exposed infants and postnatally-exposed children; and an increase in blood pressure in middle-aged men (ATSDR, 1991).

Meaningful oral and inhalation RfDs cannot be developed for lead. This difficulty reflects the lack of established thresholds for many of this metal's noncancerous effects in infants and young children. This mechanistic consideration, in addition to the existence of multimedia exposure pathways, has led to the development of U/BK modeling approaches for the health assessment of lead. The U/BK model for lead developed by the USEPA is discussed in Section 6.4.4.

Inorganic lead is classified as a Group B2 carcinogen (probable human carcinogen) based on sufficient evidence in laboratory animals. Numerous studies in rats and mice have shown statistically significant increased incidences in renal tumors with dietary and subcutaneous exposure to several soluble lead salts (USEPA, 1992). Animal assays provide reproducible results from several laboratories and in various rat strains, with some evidence of multiple tumor sites. Human evidence of carcinogenicity is inadequate because available studies lack quantitative exposure data, as well as information on the possible risk contribution from cigarette smoking (USEPA, 1992). Because the cancer risk of lead involves many uncertainties, the Carcinogen Assessment Group has not developed a SF for quantitative risk assessment (USEPA, 1992).

6.3.2 POLYCYCLIC AROMATIC HYDROCARBONS

Most of the Fort Douglas soil COCs are chemically classified as PAHs. Pure PAHs are typically colorless, white, or pale yellow-green solids. They are found attached to dust particles or in soil or sediment. They are commonly found in substances such as crude oil, coal tar pitch, creosote, and road and roofing tar.

PAHs are subject to both short- and long-range transport in the environment and are removed by wet and dry deposition. For example, PAHs can biodegrade or accumulate in plants when they are present in soil. When present in surface water, they can volatilize, photodegrade, oxidize, biodegrade, bind to particles, or accumulate in aquatic organisms. Bioconcentration factors are typically in the 100 to 2,000 range. PAHs biodegrade or accumulate in aquatic organisms when present in sediments. PAHs can enter ground water from other media and be transported within an aquifer (ATSDR, 1990).

PAHs generally have low water solubilities and can accumulate in terrestrial plants. The uptake rates via the roots or foliage are dependent on the concentration, solubility, and molecular weight of the PAH and on the plant species. Ratios of PAH concentrations in vegetation to those in soil range from 0.001 to 0.18 for total PAHs and from 0.002 to 0.33 for benzo(a)pyrene (ATSDR, 1990).

The PAH compounds are a class of organic chemicals that share common structural features (two or more joined aromatic rings) and similar toxicological, physical, and chemical properties. They are formed during incomplete burning of coal, oil, gas, garbage, or other organic substances, and are present as the main constituents of creosote (creosote is produced from the high temperature treatment of coal, certain woods, and plants). PAHs do not typically occur alone, but rather in mixtures of two or more compounds.

In general, PAHs are absorbed into the body quickly and easily through inhalation and ingestion. Once in the body, PAHs are distributed to fatty tissue and are stored primarily in the kidneys, liver, and fat. Smaller amounts of PAHs may be stored in the spleen, adrenal glands, and ovaries. Animal studies indicate that PAHs are not stored in the body for an extended period of time, but are excreted quite rapidly (ATSDR, 1990).

Although toxicological studies have been performed on various PAH-containing mixtures, only limited toxicological data are available for individual PAH compounds. Available data for quantitative risk assessment of noncarcinogenic and carcinogenic effects of PAHs are discussed in the following sections.

6.3.2.1 Noncancer Effects

Currently, the USEPA has verified oral RfDs for noncancer effects of six PAHs: acenaphthene, anthracene, fluoranthene, fluorene, naphthalene, and pyrene. Of these PAHs, only fluoranthene, naphthalene, and pyrene are identified as COCs in Fort Douglas soils. Although phenanthrene and methylnaphthalene, also identified as COCs, are considered noncarcinogenic, oral RfDs have not been determined for these compounds.

The oral RfD of 0.04 mg/kg-day for fluoranthene is based on a subchronic study in which nephropathy; increased serum glutamic-pyruvic transaminase levels; and kidney, liver, and hematological effects were observed in mice dosed by gavage with 250 mg/kg-day or 500 mg/kg-day for 13 weeks. No effects were seen in animals dosed 125 mg/kg-day. Thus, the Lowest-Observed-Adverse-Effect-Level (LOAEL) for fluoranthene derived from this data set is 250 mg/kg-day, and the NOAEL is 125 mg/kg-day. A composite uncertainty factor of 3,000 was applied to the NOAEL to account for the uncertainty that exists in animal-to-human extrapolations, the use of a subchronic study for deriving a chronic RfD, and the lack of supporting toxicity data. The confidence in the study is medium because it was a well-designed study that identified both a LOAEL and a NOAEL for several endpoints using an adequate number of animals. However, because of inadequate toxicity data for a second species, confidence in the database is low; consequently, confidence in the RfD is also low (USEPA, 1992).

The oral RfD of 0.004 mg/kg-day for naphthalene is based on a chronic study in which rats dosed with 35.7 mg/kg-day by gavage for 13 weeks showed decreases in body weight gain. An uncertainty factor of 10,000 was applied to this dose level to generate the RfD. The uncertainty factor reflects the fact that the oral RfD for naphthalene is currently under review by an EPA work group (USEPA, 1992). Because an oral RfD is not available for 2-methylnaphthalene, the oral RfD for naphthalene is used as a default RfD value for 2-methylnaphthalene to calculate noncancer risk (Sax and Lewis, 1989). Based on reported oral LD_{50}s in rats for 2-methylnaphthalene and naphthalene (1,630 mg/kg and 1,250 mg/kg, respectively), 2-methylnaphthalene is considered slightly less acutely toxic than naphthalene. Thus, it is assumed that 2-methylnaphthalene is less chronically toxic than (or similar to) naphthalene.

The oral RfD of 0.03 mg/kg-day for pyrene is based on a subchronic study in which mice were dosed by gavage with pyrene for 13 weeks. Adverse kidney effects, including nephropathy and decreased kidney weights, were the critical effects observed at the LOAEL of 125 mg/kg-day. The NOAEL derived from this study is 75 mg/kg-day. A composite uncertainty factor of 3,000, applied to the NOAEL, accounts for the uncertainty inherent in animal-to-human extrapolations, the use of a subchronic study for deriving a chronic RfD, and the lack of supporting toxicity data for other species. The study confidence is medium because it is a well-designed study with both a NOAEL and LOAEL for the critical effect. However, because of inadequate supporting toxicity data, confidence in the database is low; consequently, confidence in the RfD is also low (USEPA, 1992).

6.3.2.2 Cancer Effects

The USEPA has classified the following seven PAHs as probable human carcinogens (Group B2) based on sufficient data in animals: benzo(a)anthracene, benzo(a)pyrene, benzo(b)fluoranthene, benzo(k)-fluoranthene, chrysene, dibenz(a,h)anthracene, and indeno(1,2,3-C,D)pyrene. All of these compounds produce various tumors by several different routes of administration in animals. For example, benzo(a)-pyrene has produced skin, respiratory tract, stomach, and digestive tract tumors by oral, intratracheal, inhalation, and dermal routes of administration in rodents and monkeys. Although there are no human data that specifically link exposure to any of these PAH compounds with human cancers, all of them are components of mixtures that have been associated with human cancer, such as coal tar, soot, coke oven emissions, and cigarette smoke.

The USEPA has derived cancer SFs for some, but not all, of the PAHs. Oral SF values are available for benzo(a)pyrene, benzo(a)anthracene, benzo(b)fluoranthene, benzo(k)fluoranthene, indeno[1,2,3(c,d)] pyrene (Robert McGaughy, USEPA, personal communication). However, the SF for benzo(a)pyrene is the only SF which the USEPA has officially published (USEPA, 1992).

The current oral SF for benzo(a)pyrene is 7.3 $(mg/kg\text{-}d)^{-1}$, based on a mouse feeding study that demonstrated an excess incidence of forestomach tumors (USEPA, 1992). The oral SFs for the other PAHs have been derived by USEPA by adjusting the benzo(a)pyrene oral SF by a compound-specific relative potency factor (Clement Associates, 1988). The relative potency factors which are available for the other carcinogenic PAHs are as follows: 0.15 for benzo(a)anthracene, 0.14 for benzo(b)fluoranthene, 0.07 for benzo(k)fluoranthene, 0.20 for indeno[1,2,3(c,d)] pyrene, and 0.08 for pyrene. The USEPA

currently recommends that these relative potency factors be used in quantitative risk assessment to derive SFs from the benzo(a)pyrene SF (Robert McGaughy, USEPA, personal communication).

6.4 RISK CHARACTERIZATION

The risk characterization step of this risk assessment summarizes the results of the toxicity and exposure assessments and integrates them into qualitative and quantitative expressions of risk. Noncarcinogenic health effects are characterized by comparing the estimated average daily doses with RfDs. Carcinogenic health effects are characterized by estimating the probability that an individual will develop cancer over a lifetime of exposure based on the estimated average daily doses and the cancer SFs. Health risks due to acute or short-term exposure are not quantified in this risk assessment for two reasons: 1) numerical estimates of toxicity are not available for acute exposures, and 2) the levels of contamination at Fort Douglas are low enough to indicate that adverse health effects from acute and subchronic exposures are not likely.

6.4.1 QUANTIFICATION OF CARCINOGENIC RISKS

For carcinogens, risk is estimated as an incremental probability of an individual developing cancer over a lifetime as a result of exposure to a potential carcinogen. Cancer risk for a specific carcinogen is calculated as follows:

$$\text{Risk} = \text{CDI} * \text{SF}$$

Where:

Risk = a unitless probability (e.g., 2E-5) of an individual developing cancer,

CDI = chronic daily intake averaged over 70 years (mg/kg-day); and

SF = slope factor, expressed in $(\text{mg/kg-day})^{-1}$

A cancer risk of 1E-6 represents a one-in-one million additional probability that an individual may develop cancer over a 70-year lifetime as a result of the exposure scenarios evaluated. Total pathway cancer risk is estimated by summing chemical-specific risks associated with simultaneous exposures to

multiple carcinogens. Total cancer risk is calculated by summing cancer risk across all pathways within a given exposure scenario.

Cancer risk estimates for each of the exposure pathways evaluated in this risk assessment are presented in Tables H-13 to H-18 and H-25 to H-30 of Appendix H.

The total cancer risks calculated in this risk assessment for the residential, industrial and recreational scenarios at Fort Douglas are presented in Tables 6-11 through 6-13. As can be seen from these data, the potential for additional lifetime cancer risk is highest under the residential scenario (1E-6 to 2E-6), followed by the industrial scenario (4E-7 to 6E-7) and the recreational scenario (3E-7 to 4E-7). Under all of the land use scenarios, the potential additional, lifetime cancer risk is within, or below regulatory guidelines (i.e., 1E-6 to 1E-4), as defined by the USEPA in the Role of the Baseline Risk Assessment in Superfund Remedy Selection Decisions (Clay, 1991a).

6.4.2 Quantification of Noncarcinogenic Risks

Noncarcinogenic effects are not expressed as probabilities as discussed above for carcinogenic effects. Rather, the potential for noncarcinogenic effects is evaluated by comparing an average daily dose during chronic exposure, to a reference dose derived for a chronic exposure period. This ratio is called a noncancer hazard quotient and is expressed as follows:

Noncancer hazard quotient = E/RfD

Where:

E = exposure level (or dose);

RfD = reference dose; and E and RfD are expressed in the same units and represent the same exposure period (e.g., chronic).

The noncancer hazard quotient assumes that there is a level of exposure below which health effects are unlikely to occur. If the hazard quotient exceeds one, there may be concern for noncancer health risks. Exposures resulting in a hazard quotient of less than one are unlikely to result in adverse health effects. Conversely, the higher the quotient is above one, the greater the probability that adverse health effects will result. To determine the overall hazard index (HI) for simultaneous exposures, hazard quotients are

Table 6-11 Pathway Specific and Total Cancer Risk for the Residential Scenario

Building 39 Area

Pathway	Cancer Risk
Ingestion of Soil	8.7E-7
Dermal Contact with Soil	5.1E-7
Total Cancer Risk	1E-6

Southeast Fence Line Area

Pathway	Cancer Risk
Ingestion of Soil	1.3E-6
Dermal Contact with Soil	7.6E-7
Total Cancer Risk	2E-6

Table 6-12 Pathway Specific and Total Cancer Risk for the Industrial Scenario

Building 39 Area

Pathway	Cancer Risk
Ingestion of Soil	9.7E-8
Dermal Contact with Soil	2.9E-7
Total Cancer Risk	4E-7

Southeast Fence Line Area

Pathway	Cancer Risk
Ingestion of Soil	1.4E-7
Dermal Contact with Soil	4.3E-7
Total Cancer Risk	6E-7

Table 6-13 Pathway Specific and Total Cancer Risk for the Recreational Scenario

Building 39 Area

Pathway	Cancer Risk
Ingestion of Soil	1.3E-7
Dermal Contact with Soil	1.3E-7
Total Cancer Risk	3E-7

Southeast Fence Line Area

Pathway	Cancer Risk
Ingestion of Soil	1.9E-7
Dermal Contact with Soil	1.9E-7
Total Cancer Risk	4E-7

summed for those chemical hazards which affect the same target organ (or tissue) within a given exposure pathway. HIs for all exposure pathways are then summed according to target tissue, in order to determine the total HI for each target tissue, within a given exposure scenario.

Hazard Quotients for the individual exposure pathways evaluated in this risk assessment are presented in Tables H-19 to H-24 and H-31 to H-36 of Appendix H. As these data indicate, all Hazard Quotients are markedly less than one for all exposure pathways and exposure scenarios. Because all Hazard Quotients are several orders of magnitude less than one, target organ-specific HIs are not calculated in this evaluation. Based on these data, noncancerous health effects are not likely to occur on Fort Douglas under the exposure conditions defined in this risk assessment.

6.4.3 Risk Characterization for TPH

As indicated previously, concentrations of TPH as high as 6,000 ppm were detected in soils taken from the Southeast Fence Line Area (see Table 6-5). Also, as discussed earlier, the quantitative toxicological significance of this finding cannot be addressed due to the lack of chemical-specific information about TPH.

Qualitatively, PAHs are generally found in TPH, and the results of the GC/MS analyses of Fort Douglas soils suggest the presence of PAHs in the TPH. Toxicologically, several PAHs have been classified by the USEPA as probable human carcinogens. Therefore, all PAHs detected in soil have been fully evaluated in the risk assessment. Other known constituents of TPH that are harmful to human health (e.g., BTEX) were not detected. The remainder of the hydrocarbons detected by the TPH analysis are not known to be of concern to human health or the environment.

6.4.4 Risk Characterization for Lead

In risk assessment, the potential for noncancer effects associated with exposure to lead is evaluated differently from other chemicals for two primary reasons. First, although many studies have evaluated the effects of low-level exposure to lead, the USEPA study groups have not reached a consensus on a threshold level for lead exposure. It appears that some of lead's effects, particularly those associated with certain blood enzymes and neurobehavioral development, may occur at blood-lead levels so low as to be essentially without a threshold. As a result, no RfD has been established for lead, even though adverse

effects are well known. Second, lead is ubiquitous in the environment, coming from a variety of sources including air pollution, diet, water pipes, soils, and paints. Since exposure is rarely limited to one individual pathway, hazards associated with lead cannot be fully evaluated without regard to other environmental contributors. In light of these issues, the USEPA has developed the U/BK model (USEPA, 1990a,b), which integrates the various exposure pathways, to characterize risks due to lead exposure.

Although the USEPA recognizes the U/BK model as the best available risk assessment tool for residential sites, the USEPA does not expect to issue a revised directive establishing the U/BK model as the preferred method for developing site-specific cleanup levels for lead in soil until a site-specific guidance manual (currently in preparation) is completed (Clay, 1991b). The current Office of Solid Waste and Emergency Response (OSWER) directive for lead suggests lead levels ranging from 500 to 1,000 mg/kg as target levels for cleanup at hazardous waste sites (Longest and Diamond, 1989). When the U/BK model is run using the USEPA's default parameters and health protection benchmark (95 percent of the sensitive population having blood lead levels below 10 μg/dL), an acceptable soil lead level of approximately 500 mg/kg is predicted, which is consistent with the lower reference level of the current OSWER directive (Clay, 1991b).

The levels of lead in Fort Douglas surface soils are slightly elevated in source areas as compared to background areas (Tables 6-2 and 6-3). The concentration of lead detected in source area surface soils ranged from 10 to 320 mg/kg, while the concentrations of lead detected in background area surface soils ranged from 14 to 82 mg/kg (with a geometric mean 95UCL of 91 mg/kg). The mean exposure-point concentration in source area soils is calculated to be 60 mg/kg in the Building 39 Area (Table 6-6) and 180 mg/kg in the Southeast Fence Line Area (Table 6-7).

A comparison between Fort Douglas data and the USEPA's suggested soil lead concentration of 500 mg/kg indicates that soil lead levels at Fort Douglas are well within current federal guidelines. This comparison suggests that there is a low level of risk for young children who would experience a chronic exposure to lead in Fort Douglas soils.

6.5 UNCERTAINTY ANALYSIS

Uncertainties are associated with each step in the risk assessment process which may influence the results of the risk assessment. Many uncertainties are generic to the risk assessment process, while others are

site-specific. The major sources of uncertainty in this risk assessment are identified below for each of the four risk assessment steps.

6.5.1 UNCERTAINTIES ASSOCIATED WITH IDENTIFICATION OF COCs

The uncertainties associated with identifying COCs include:

- Potential risks associated with chemicals intentionally excluded from the risk assessment, and
- Potential risks associated with chemicals unintentionally excluded from the risk assessment.

As discussed in Section 6.1, not all contaminants detected in Fort Douglas soils are included as COCs in this assessment. Some organic and inorganic contaminants were eliminated on the basis of probable laboratory contamination. Several inorganic contaminants were also eliminated on the basis of their natural occurrence in soil and the fact that their detected levels in source areas were similar to those detected in the background areas. Although these contaminants were intentionally eliminated from the risk assessment, it is unlikely that any of them pose a significant risk to human health at the facility because their detected concentrations are well below USEPA health-based Proposed Soil Action Levels.

Potential risks associated with chemicals unintentionally excluded from the risk assessment also constitute a source of uncertainty in the risk assessment. Although the EI included an assessment of all media where site-related chemicals are suspected to be present because of past activities at Fort Douglas, some unidentified contaminants could potentially be present. Thus, chemicals that may be present on site, but not identified in the EI, could be the cause of underestimation of total site risks. However, the sampling rationale used in the EI was selected based on the operational history of the post, thus minimizing the possibility of unintentional exclusion of site-related contaminants.

6.5.2 UNCERTAINTIES ASSOCIATED WITH EXPOSURE ASSESSMENT

The greatest number of site-specific uncertainties is associated with the exposure assessment. The most significant uncertainties associated with this step that may influence the results of the risk assessment include:

- Assumptions used to estimate exposure-point concentrations and intake variables,
- Difficulties in accurately characterizing exposure under future land uses, and
- Risks associated with potential exposure pathways excluded from the risk assessment.

The degree to which the field sampling data accurately reflect levels of contamination present at Fort Douglas is a source of uncertainty. Soil contaminant concentrations greater than those detected in the field sampling program may or may not exist. Because of this type of uncertainty, however, the 95UCL of the arithmetic mean is conservatively used in this assessment to estimate the average exposure-point concentrations for all COCs. This method is likely to result in an over-estimation of the true mean concentration of those COCs which are accurately represented by the sampling data. Because the soil concentration data exhibit a log-normal rather than a normal distribution, the 95UCL of the arithmetic mean over-estimates the true mean concentration; the 95UCL of the geometric mean more accurately presents this concentration. However, use of the 95UCL of the geometric mean is not as protective as the use of the 95UCL of the arithmetic mean, in light of the uncertainties.

As noted above, another source of uncertainty associated with exposure assessment is the difficulty in accurately characterizing exposure under future land use. In this risk assessment, several assumptions are made which may or may not accurately represent future land use conditions. For example, it is unclear how the University of Utah will use the buildings on the facility (i.e., to house students, faculty, or administrative personnel during working hours). In light of this uncertainty, the assumption is made that children will reside on site and will live there continuously for 30 years. This assumption is questionable, but protective in light of the uncertainty.

6.5.3 UNCERTAINTIES ASSOCIATED WITH TOXICITY ASSESSMENT

Most of the major uncertainties associated with toxicity assessment are generic to the risk assessment process and include the following:

a) Dose-response information from animal studies has been used to predict effects in humans.

b) Dose-response information from effects observed in animals at high doses has been used to predict adverse health effects in humans who will likely be exposed to low levels of contamination found in the environment.

c) Dose-response information from short-term exposure studies has been used to predict the effects of long-term exposure.

d) Dose-response information from genetically homogenous animal populations and from healthy human populations has been used to predict adverse effects in the general population, which consists of individuals with a wide range of sensitivities (sensitive human subpopulations).

e) Dose-response information has been used from a variety of animal species whose observed effects differ markedly.

f) Numerical estimates of toxicity, both for cancerous and non-cancerous effects, are unavailable for a majority of the COCs, including the chemical constituents of TPH.

g) Potential synergistic or antagonistic interactions may occur between chemicals to which the same individual may be exposed.

Because of the above uncertainties associated with toxicity assessment, risk assessment methods are designed to be highly conservative to ensure protectiveness. For example, estimates of cancer risk are likely to be over-estimations of actual cancer risks because USEPA-derived SFs are based on the upper

95th-percentile risk estimates in the carcinogenesis dose-response model. The use of multiplicative uncertainty factors in the derivation of RfDs is also devised to be health protective.

A source of uncertainty specific to this risk assessment is the assumption that the toxicity values for benzo(a)pyrene and a few other PAHs are representative of the inherent toxicity of the PAHs as a class. This assumption was made in order to assess the potential health risks associated with exposure to several PAHs for which compound-specific toxicity values are not available. Based on the close structural similarity among the PAHs, it is plausible that their inherent toxicities are similar. However, should marked differences in their toxicity actually exist, the risk estimates calculated in this assessment could be either under-, or over-represented.

6.5.4 UNCERTAINTIES ASSOCIATED WITH RISK CHARACTERIZATION

The uncertainties associated with risk characterization include:

- The validity of assuming that cancer risk is equivalent at all ages, regardless of when exposure occurs,
- The validity of adding risks or hazard quotients for multiple chemicals, and
- The validity of adding risks or hazard quotients across pathways.

Although it is current USEPA policy to characterize carcinogenic risk without regard to age at the time of exposure, this approach becomes problematic as exposures become less frequent or shorter in duration (USEPA, 1989b). Also, this approach does not account for the age at onset of exposure, and therefore assumes that exposure to a carcinogen for a given period of time poses the same carcinogenic risk to all individuals, regardless of age. However, for some genotoxic carcinogens, experimental data suggest that a dose applied early in life can have a different effect than the same dose applied later in life. Thus, uncertainty associated with risk characterization of carcinogens, particularly genotoxic carcinogens, increases as exposure duration decreases.

A comparison of the USEPA approach of characterizing carcinogenic risk to an alternative approach provides one measure of the magnitude of uncertainty. Crump and Howe (1984) present an alternative

model for calculating risks associated with exposure to carcinogens that adjusts for age at the onset of exposure. In comparison to the USEPA approach for calculating the CDI and risk associated with a 30-year exposure, this alternative model estimates greater risks to individuals whose exposure begins before age 16 and lower risks to individuals whose exposure begins after age 16. Specifically, the Crump and Howe model predicts risks which are about two-fold higher than risks predicted by the USEPA approach if exposure begins at birth, but less than one-fifth the risk if exposure begins at age 45. Thus, the difference in risk estimates developed using the USEPA approach versus the Crump and Howe model may span as much as one-half an order of magnitude; however, for the large majority of individuals (i.e., those over age 16), the USEPA method provides a higher (i.e., more conservative) estimate of risk.

7.0 SUMMARY AND CONCLUSIONS

Historical activities at Fort Douglas have not included major industrial processes. Since its establishment in 1862, Fort Douglas has been primarily used to garrison troops, house prisoners of war, serve as headquarters for military units, and function as a support detachment for military activities in the region. Activities supporting these operations primarily have included maintenance and repair of base facilities and vehicles. As a result, environmental media on the excessed area of Fort Douglas have not been significantly impacted.

Potential releases from areas associated with the maintenance and repair of base facilities and vehicles were investigated by soil borings and surface soil samples. Analytical results indicate that three locations exhibit soil contamination: 1) the former wash rack/oil change/degreasing area near Building 39, 2) a concrete drainage ditch near the southeast fence line, and 3) an area adjacent to a paved drum and fuel storage area at Building 132 that apparently was used for disposal of various types of post waste. The constituents detected consist of hydrocarbons (TPH, PAHs) and heavy metals. Four additional areas that were investigated by soil samples did not exhibit elevated levels of organics or inorganics: 1) the former UST sites near Building 39, 2) an area near the southeast fence line historically used for disposal of post waste, but apparently not associated with the more recent maintenance and storage operations and potential disposal of related equipment (oil filters, etc.), 3) the outlet of a culvert that extends from a sump and wash rack area near Building 134 to the excessed area, and 4) an area downslope from a University of Utah storage yard used primarily for storage of drums, transformers, and miscellaneous equipment.

In the wash rack/oil change/degreasing area near Building 39, hydrocarbons (TPH, PAHs) were released to the surface and subsurface soils. Hydrocarbons were detected in the deepest samples, collected to depths of 5.0 and 3.2 ft bgs. Sod covered the area. Pieces of black-stained concrete, likely remnants of the wash rack or grease pit structures, were recovered with the soil samples. The detected hydrocarbons primarily were heavy oils, such as used motor oils or lubricants.

Hydrocarbons (TPH, PAHs) were detected in the surface soil samples (0.0 to 0.5 ft bgs) collected from and near the concrete drainage ditch. A sample collected below this interval did not contain elevated levels of hydrocarbons or other compounds, indicating that contaminated soil may have been carried in surface water run-off to the excessed area, and migration to subsurface soils had not occurred.

Man-made or used materials, including pieces of brick, ceramic, coal, cast-iron pipe, and masonry were present in the soil samples that were collected from two borings drilled to investigate the drum and fuel storage area near Building 132. In addition, three used oil filters were on the ground surface in the vicinity of the surface soil samples. The presence of these materials indicated this area may have been intermittently used for disposal of post waste. Hydrocarbons (TPH and PAHs), and levels of heavy metals that exceeded concentrations detected in background soil samples were reported in surface and subsurface soils in this area. The contaminants may have been released from some of these materials to the soil, and/or may have been transported by surface water from possible spills or leaks from storage containers in the adjoining storage area. Samples deeper than 3.4 ft bgs were not collected. Contaminants were detected in the deepest sampled intervals.

The potential COCs detected in the soils, heavy petroleum hydrocarbons, PAHs, and metals, typically are immobile, slowly biodegradable or nonbiodegradable, persistent, and sorb to soil. Little or no migration of site-related contaminants from the wash rack/oil change/degreasing area is expected to occur. Migration from surface soils in the Southeast Fence Line Area is possible, if the contaminants were transported adsorbed to sediment carried by surface water, off-site to Red Butte Creek; however, given the limited amount of contamination on site, it is unlikely that a significant amount of contamination has impacted the creek. In addition, the creek is not used for human consumption, and swimming is not permitted. Migration to ground water from the creek or from the soil also is unlikely, due to the depth to the regional aquifer (350 ft bgs), the general immobility of the contaminants, and the limited amount of contamination. The vegetative cover and the absence of vehicular traffic in both areas indicate that air transport of the contaminants sorbed to surface soil particulates would be of minor significance.

Investigations of transformer oil, asbestos, lead-based paint, and radon, and remediation of the asbestos and radon associated with Fort Douglas structures also were conducted at Fort Douglas. Two of the 24 sampled, pole-mounted transformers contained PCB 1260 at a concentration of 200 $\mu g/g$. These two transformers were in fair to poor condition, but there was no indication the transformer oil had reached the ground. Lead-based paints were found in Fort Douglas buildings, as detected in paint chip and paint wipe samples. Fort Carson conducted monitoring of radon levels, and attempted to mitigate structures with radon levels measuring 3.3 pCi/L and above, as measured in 10 structures. These structures are being retested by Fort Carson. In addition, asbestos sampling and assessment of the asbestos data were performed by WJE. Based on the assessment, asbestos encapsulation was conducted in some of the buildings by Fort Carson.

Potential health risks associated with soil contamination were evaluated by the risk assessment. Three separate exposure scenarios were evaluated in the risk assessment: a residential, an industrial, and a recreational scenario. Under each of the three exposure scenarios, two exposure pathways were evaluated: incidental ingestion of contaminated soil and dermal absorption of contaminants in soil. A toxicity assessment of the soil COCs indicated that both cancerous and noncancerous adverse health effects are of potential concern at the site, if significant exposure were to occur in sufficient quantities. The risk characterization, however, revealed that all cancer risk estimates fall within or below the acceptable range as defined by the USEPA (1E-6 to 1E-4). Additionally, all Hazard Indices were markedly less than one. These results indicate that remedial action for these compounds (PAHs, inorganics) is not warranted.

While soil lead levels at the site are well below current USEPA guidelines for soil, lead-based paint on residential buildings at a federal facility is regulated by federal law when the property is sold or transferred. In addition, the levels of lead detected in some paint chip samples collected from the buildings exceed HUD criteria for defining a lead-based paint hazard in building interiors.

This Environmental Investigation Report has been reviewed by appropriate departments within State of Utah and Federal (USEPA) regulatory agencies. One department—The State of Utah Department of Environmental Quality, Division of Environmental Response and Remediation—asserts that data gaps exist in the Environmental Investigation. Their areas of concern include 1) the regional groundwater aquifer, 2) storage/use of pesticides, and 3) impacts of site contamination on Red Butte Creek. The USAEC maintains that additional investigation of these areas is not necessary, based on the following rationale:

- Investigation of the regional aquifer is unwarranted because 1) the detected contaminants are highly immobile (i.e. they strongly attenuate to soil), and 2) the depth to the regional aquifer is approximately 350 ft. Migration of these contaminants, through this thickness of sediments, is highly unlikely.

- Additional efforts to investigate the storage of pesticides is unwarranted because the pesticides, used for routine application, were stored on the property that is being retained by the Army.

- Investigation of Red Butte Creek is unwarranted because 1) subsurface migration is not towards the creek, 2) surface migration to the creek occurs from many upstream sources, and 3) the contaminants detected in soil near the creek are known to be ubiquitous (near-uniformly present) in metropolitan areas. These factors indicate that additional investigations would be inconclusive, relative to the impact of the site on the creek. Further, because the human and ecologic risk posed by the on-site contamination is below regulatory concern, it is improbable that this risk would be significantly increased by migration to the creek.

The Army believes, based on these and all relevant and probable factors, that it has investigated all foreseeable sources which would potentially pose a significant threat to human health or the environment. Therefore, the Army feels that the requirements for the transfer of the closure (excessed) portion of Fort Douglas to the University of Utah have been met.

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